华为认证系列教程

HCDA-HNTD
华为网络技术与设备
实验指导书

HUAWEI

华为技术有限公司

版权声明

版权所有 © 华为技术有限公司 2012。 保留一切权利。

本书所有内容受版权法保护，华为拥有所有版权，但注明引用其他方的内容除外。未经华为技术有限公司事先书面许可，任何人、任何组织不得将本书的任何内容以任何方式进行复制、经销、翻印、存储于信息检索系统或使用于任何其他任何商业目的。

版权所有 侵权必究。

商标声明

和其他华为商标均为华为技术有限公司的商标。

本文档提及的其他所有商标或注册商标，由各自的所有人拥有。

华为认证系列教程

HCDA-HNTD华为网络技术与设备

实验指导书

第1.6版本

华为认证体系介绍

依托华为公司雄厚的技术实力和专业的培训体系，华为认证考虑到不同客户对ICT技术不同层次的需求，致力于为客户提供实战性、专业化的技术认证。

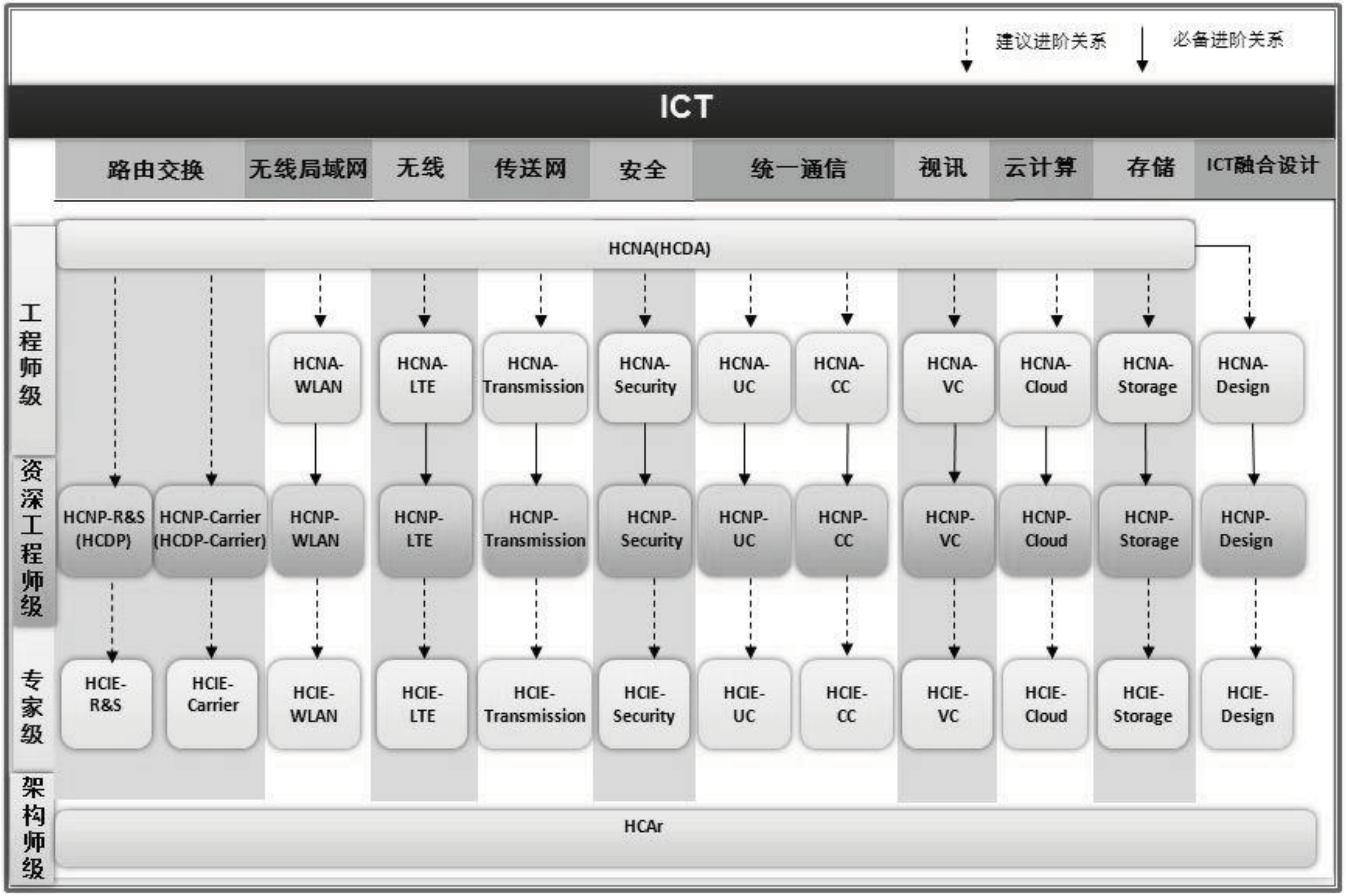
根据ICT技术的特点和客户不同层次的需求，华为认证为客户提供面向十三个方向的四级认证体系。

HCDA(Huawei Certified Datacom Associate ,华为认证数据通信工程师）主要面向IP网络维护工程师，以及其他希望学习IP网络知识的人士。HCDA认证在内容上涵盖TCP/IP基础、路由、交换等IP网络通用基础知识以及华为数据通信产品、通用路由平台VRP特点和基本维护。

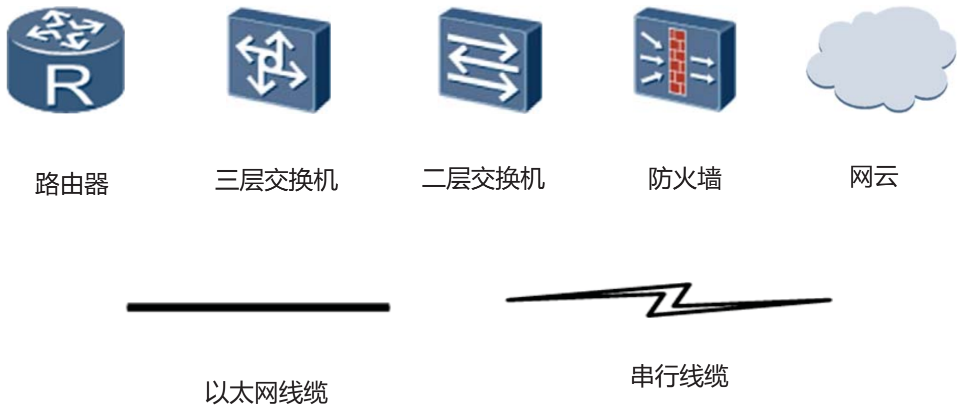
HCDP-Enterprise (Huawei Certified Datacom Professional-Enterprise，华为认证数据通信资深工程师-企业级)主要面向企业级网络维护工程师、网络设计工程师以及希望系统深入地掌握路由、交换、网络调整及优化技术的人士。HCDP-Enterprise包括IESN（Implementing Enterprise Switching Networks，部署企业级交换网络）、IERN(Implementing Enterprise Routing Networks，部署企业级路由网络）、IENP(Improving Enterprise Network Performance，提升企业级网络性能）三个部分。内容上涵盖IPv4路由技术原理深入以及在VRP中的实现；交换技术原理深入以及在VRP中的实现；网络安全技术、高可靠性技术和Qos技术等高级IP网络技术以及在华为产品中的实现。

HCIE（Huawei Certified Internetwork Expert，华为认证互联网络专家）旨在培养能够熟练掌握各种IP网络技术；精通华为产品的维护、诊断和故障排除；具备大型IP网络规划、设计和优化的IP网络大师。

华为认证协助您打开行业之窗，开启改变之门，屹立在ICT世界的潮头浪尖！


建议进阶关系
必备进阶关系
ICT
路由交换
无线局域网
无线
传送网
安全
统一通信
视讯
云计算
存储
ICT融合设计
工程师级
资深工程师级
专家级
架构师级
HCNA(HCDA)
HCNA-WLAN
HCNA-LTE
HCNA-Transmission
HCNA-Security
HCNA-UC
HCNA-CC
HCNA-VC
HCNA-Cloud
HCNA-Storage
HCNA-Design
HCNP-R&S (HCDP)
HCNP-Carrier (HCDP-Carrier)
HCNP-WLAN
HCNP-LTE
HCNP-Transmission
HCNP-Security
HCNP-UC
HCNP-CC
HCNP-VC
HCNP-Cloud
HCNP-Storage
HCNP-Design
HCIE-R&S
HCIE-Carrier
HCIE-WLAN
HCIE-LTE
HCIE-Transmission
HCIE-Security
HCIE-UC
HCIE-CC
HCIE-VC
HCIE-Cloud
HCIE-Storage
HCIE-Design
HCAr

本书常用图标



实验环境说明

组网介绍

本实验环境面向准备HCDA-HNTD考试的网络工程师，内容由HCDA-HNTD的VRP基础操作、路由协议原理、以太网交换技术、广域网技术、网络安全技术等部分的实验组成。

实验设备包括路由器3台，交换机4台，防火墙1台。每套实验环境适用于2名学员同时上机操作。

设备介绍

为了满足HCDA-HNTD实验需要，建议每套实验环境采用以下配置：

设备名称、型号与版本的对应关系如下：

设备名称	设备型号	软件版本
R1	AR 2220	Version 5.90 (V200R001C01SPC300)
R2	AR 2220	Version 5.90 (V200R001C01SPC300)
R3	AR 2220	Version 5.90 (V200R001C01SPC300)
S1	S5700-28C-EI-24S	Version 5.70 (V100R006C00SPC800)
S2	S5700-28C-EI-24S	Version 5.70 (V100R006C00SPC800)
S3	S3700-28TP-EI-AC	Version 5.70 (V100R006C00SPC800)
S4	S3700-28TP-EI-AC	Version 5.70 (V100R006C00SPC800)
FW	USG2160	Version 5.30 (V300R001C00SPC700)

目录

第一章 VRP平台基本操作 1

实验 1-1 VRP平台基本操作 1

第二章 静态路由及默认路由 21

实验 2-1 静态路由及默认路由 21

第三章 RIP的配置 39

实验 3-1 RIPv1&v2配置 39

实验 3-2 RIPv2路由汇总和认证 56

第四章 OSPF的配置 71

实验 4-1 OSPF单区域配置 71

实验 4-2 OSPF多区域、认证配置 86

第五章 RIP、OSPF相互引入路由 100

实验 5-1 RIP、OSPF相互引入路由 100

第六章 以太网及生成树协议 111

实验 6-1 以太网接口及链路配置 111

实验 6-2 STP配置 118

实验 6-3 VLAN配置 130

第七章 三层交换与虚拟路由器冗余协议 140

实验 7-1 三层交换 140

实验 7-2 VRRP配置 153

第八章 广域网技术 168

实验 8-1 HDLC与PPP配置 168

实验 8-2 帧中继（背靠背）配置 183

实验 8-3 帧中继（FR交换机环境）配置 203

第九章 防火墙技术 219

实验 9-1 USG防火墙基本配置 219

实验 9-2 USG防火墙区域配置 232

实验 9-3 USG防火墙NAT配置 245

第十章 综合实验 257

实验 10-1 综合实验 257

第一章 VRP平台基本操作

实验 1-1 VRP 平台基本操作

学习目的

- 掌握通过Windows自带终端软件连接到路由器的配置
- 掌握配置设备名称、时间及时区的方法
- 掌握配置Console口空闲超时的方法
- 掌握配置登录欢迎信息的方法
- 掌握配置登陆密码与Super密码的方法
- 掌握保存和删除配置文件的方法
- 掌握路由器接口配置IP地址的方法
- 掌握直连的两个路由器之间的连通测试方法
- 掌握使用通过Telnet一台路由器去控制另外一台路由器的配置方法
- 掌握使用FTP将配置文件从一台路由器拷贝到另一台路由器的方法
- 掌握重启路由器的方法

拓扑图



图1.1 VRP平台基本操作实验拓扑图

场景

公司刚买了两台ARG3路由器，在使用之前，需要你对它们进行调试。调试的内容覆盖了配置方式、设备名称、时间、密码、文件管理及重启等方面。

学习任务

步骤一. 设备连接

通过Windows XP系统自带超级终端连接路由器的方法。

用Console线缆将PC电脑连接至路由器的Console接口。在计算机上打开终端仿真程序（如Windows XP的超级终端），如下图建立一个新的连接。这里的名称和图标无特殊意义，可以随自己喜好定义和选择。



图1.2 建立新的连接

选择配置的方式，确定所使用的COM口。



图1.3 连接接口选择

在拥有多个COM口的计算机上，请注意选择正确的COM接口，一般情况下计算机的串口为COM1。



图1.4 接口通信参数设置

在COM1的属性界面中，点击“还原为默认值”，即可快速得到正确的参数信息的配置。然后点击“确定”进行连接。

打开电源，开启路由器。如果以上参数设置正确，终端窗口会有启动过程文

字出现，直到启动完毕，提示用户按Enter键。用户视图的命令行提示符，如<Huawei>会出现，至此用户进入了用户视图配置环境。

步骤二. 显示系统信息

首先可以使用**display version**命令显示系统软件版本及硬件等信息。

```
<Huawei>display version
Huawei Versatile Routing Platform Software
VRP (R) software, Version 5.90 (AR2200 V200R001C01SPC300)
Copyright (C) 2011 HUAWEI TECH CO., LTD
Huawei AR2220 Router uptime is 0 week, 0 day, 0 hour, 2 minutes
BKP 0 version information:
……output omit……
```

注意其中可以看到VRP操作系统的版本，设备的型号，启动时间等信息。

步骤三. 修改和查看设备系统时间参数

系统会自动保存时间，但是如果时间错误了，可以在用户视图下使用**clock datetime**命令修改系统日期和时间。

```
<Huawei>clock datetime 12:00:00 2011-09-15
```

使用**display clock**命令查看当前系统日期和时间。

```
<Huawei>display clock
2011-09-15 12:00:21
Thursday
Time Zone(Default Zone Name) : UTC+00:00
```

步骤四. 使用“？”键和“Tab”键

```
<Huawei>display ?
  aaa                         AAA
  access-user                  User access
  accounting-scheme             Accounting scheme
  acl                         <Group> acl command group
  adp-ipv4                     Ipv4 information
  adp-mpls                     Adp-mpls module
  anti-attack                  Specify anti-attack configurations
  arp                         <Group> arp command group
```

```
 arp-limit                    Display the number of limitation
 atm                        ATM status and configuration information
 authentication-scheme          Authentication scheme
 authorization-scheme           Display AAA authorization scheme
……output omit……
```

在输入信息后输入“？”可查看以输入的字母开头的命令。如输入“dis？”，设备将输出所有以dis开头的命令。

在输入的信息后增加空格，再输入“？”，这时设备将尝试识别输入的信息对应的命令，然后输出该命令的其他参数。例如输入“dis ？”，如果只有**display**命令是以dis开头的，那么设备将输出**display**命令的参数，如上所示；如果以dis开头的命令还有其他的，设备将报错。

另外可以使用键盘上Tab键补全命令，比如键入“dis”后，按键盘“Tab”键可以将命令补全为“display”。如有多个以“dis”开头的命令存在，则在多个命令之间循环切换。

命令在不发生歧义的情况下可以使用简写，如“display”可以简写为“dis”或“disp”等，“interface”可以简写为“int”或“inter”等。

步骤五.　进入系统视图界面

使用**system-view**命令可以进入系统视图，这样才可以配置接口、协议等内容。

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]
```

步骤六.　修改设备名称

配置设备时，为了便于区分配置的设备，往往给设备定义不同的名称。如下我们依照实验拓扑图，修改设备名称。

更改R1路由器的系统名称为R1。

```
[Huawei]sysname R1
[R1]
```

更改R2路由器的系统名称为R2。

```
[Huawei]sysname R2
[R2]
```

步骤七. 配置登录标语信息

配置登陆标语信息来进行提示或进行登陆警告。

```
[R1]header shell information "Welcome to Huawei certification lab"
```

使用以上命令配置标语信息，然后尝试退出路由器命令行界面重新登录，查看欢迎信息

```
[R1]quit
<R1>quit

  Configuration console exit, please press any key to log on
Welcome to Huawei certification lab
<R1>
```

请注意，通常情况下，登陆标语信息用于警告非法登陆，所以请勿使用欢迎类词语。

步骤八. 配置 Console 口登录认证方式及超时时间

默认情况下，通过Console口登陆无密码，任何人可以直接连接到设备，进行配置。

为避免由此带来的风险 ,可以将Console接口登录方式配置为密码认证方式，密码为明文形式的“huawei”。

空闲时间指的是经过没有任何操作的一定时间后，会自动退出该配置界面，再次登陆会根据系统要求，提示输入密码进行验证。

设置空闲超时时间为20分钟，默认为10分钟。

```
[R1]user-interface console 0
[R1-ui-console0]authentication-mode password
[R1-ui-console0]set authentication password simple huawei
[R1-ui-console0]idle-timeout 20 0
```

使用**display this**命令检查配置结果。

```
[R1-ui-console0]display this
[V200R001C01SPC300]
#
user-interface con 0
 authentication-mode password
 set authentication password simple huawei
```

```
 idle-timeout 20 0
```

这时退出路由器尝试重新登录，测试重新登陆是否需要输入密码。

```
[R1-ui-console0]return
<R1>quit

Password:
  Configuration console exit, please press any key to log on
Welcome to Huawei certification lab
<R1>
```

步骤九. 接口 IP 配置及描述

为R1的S1/0/0接口配置IP地址，配置IP地址时可以使用子网掩码长度，也可以使用完整的子网掩码，如掩码为255.255.255.0，也可以使用24替代。

```
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 24
[R1-Serial1/0/0]description This interface connect to R2-S1/0/0
```

使用**display this**命令检查配置结果

```
[R1-Serial1/0/0]display this
[V200R001C01SPC300]
#
interface Serial1/0/0
 link-protocol ppp
 description This interface connect to R2-S1/0/0
ip address 10.0.12.1 255.255.255.0
#
Return
```

使用**display interface**命令查看接口详细信息

```
[R1-Serial1/0/0]display interface Serial1/0/0
Serial1/0/0 current state : UP
Line protocol current state : UP
Last line protocol up time : 2011-09-15 17:38:48
Description:This interface connect to R2-S1/0/0
Route Port,The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is 10.0.12.1/24
Link layer protocol is PPP
```

```
LCP opened, IPCP stopped
Last physical up time   : 2011-09-16 17:38:45
Last physical down time : 2011-09-16 17:38:34
Current system time: 2011-09-16 17:42:58
Physical layer is synchronous, Baudrate is 64000 bps
Interface is DCE, Cable type is V35, Clock mode is DCECLK
Last 300 seconds input rate 2 bytes/sec 16 bits/sec 0 packets/sec
Last 300 seconds output rate 2 bytes/sec 16 bits/sec 0 packets/sec
Input: 212 packets, 2944 bytes
  broadcasts:          0,  multicasts:          0
  errors:              0,  runts:               0,  giants:              0
  CRC:                 0,  align errors:        0,  overruns:            0
  dribbles:            0,  aborts:              0,  no buffers:          0
  frame errors:        0
Output: 216 packets, 2700 bytes
  errors:              0,  underruns:           0,  collisions:          0
  deferred:            0
DCD=UP DTR=UP DSR=UP RTS=UP CTS=UP

    Input bandwidth utilization  : 0.13%
    Output bandwidth utilization : 0.13%
[R1-Serial1/0/0]
```

接口信息显示，接口物理状态和协议状态均为“UP”，对应物理层和数据链路层状态正常。

此外可以看到接口连接的线缆类型为V.35 DCE。

完成后配置R2的接口地址及其他相关信息。

```
[R2]interface Serial 1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 255.255.255.0
[R2-Serial1/0/0]description This interface connect to R1-S1/0/0
[R2-Serial1/0/0]
```

配置完成后，使用**ping**命令测试R1与R2之间的连通性。

```
[R1]ping 10.0.12.2
  PING 10.0.12.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.12.2: bytes=56 Sequence=1 ttl=255 time=35 ms
    Reply from 10.0.12.2: bytes=56 Sequence=2 ttl=255 time=32 ms
    Reply from 10.0.12.2: bytes=56 Sequence=3 ttl=255 time=32 ms
    Reply from 10.0.12.2: bytes=56 Sequence=4 ttl=255 time=32 ms
    Reply from 10.0.12.2: bytes=56 Sequence=5 ttl=255 time=32 ms
  --- 10.0.12.2 ping statistics ---
```

```
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 32/32/35 ms
```

步骤十.　Telnet 配置

为R1配置Telnet登录方式为密码验证登录，设置密码为“huawei”，定义用户权限级别为3。

```
[R1]user-interface vty 0 4
[R1-ui-vty0-4]authentication-mode password
[R1-ui-vty0-4]set authentication password simple huawei
[R1-ui-vty0-4]user privilege level 3
```

使用**display this**命令检查配置结果。如下

```
[R1-ui-vty0-4]display this
[V200R001C01SPC300]
#
user-interface con 0
 authentication-mode password
 set authentication password simple huawei
 idle-timeout 20 0
user-interface vty 0 4
 user privilege level 3
 set authentication password simple huawei
user-interface vty 16 20
#
return
```

为R2配置Telnet登录方式为用户名+密码登录方式

```
[R2]user-interface vty 0 4
[R2-ui-vty0-4]authentication-mode aaa
[R2-ui-vty0-4]quit
```

提示：使用**quit**命令可以退回到上一层视图，使用**return**命令则可以直接退回到用户视图。

```
[R2]aaa
[R2-aaa]local-user huawei password simple huawei
[R2-aaa]local-user huawei privilege level 15
[R2-aaa]local-user huawei service-type telnet
```

使用**display this**命令检查配置结果

```
[R2-aaa]display this
[V200R001C01SPC300]
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password simple admin
 local-user admin service-type http
 local-user huawei password simple huawei
 local-user huawei privilege level 15
 local-user huawei service-type telnet
#
Return
```

从R1 使用Telnet方式登陆到R2。

```
<R1>telnet 10.0.12.2
  Press CTRL_] to quit telnet mode
  Trying 10.0.12.2 ...
  Connected to 10.0.12.2 ...

Login authentication

Username:huawei
Password:

----------------------------------------------------------------------------
  User last login information:

----------------------------------------------------------------------------
  Access Type: Telnet
  IP-Address : 10.0.12.1
  Time       : 2011-09-14 13:19:59+00:00

----------------------------------------------------------------------------
<R2>
```

成功Telnet登录到R2。

使用Telnet工具从R2登陆到R1。

```
<R2>telnet 10.0.12.1
  Press CTRL_] to quit telnet mode
  Trying 10.0.12.1 ...
  Connected to 10.0.12.1 ...

Login authentication

Password:
Welcome to Huawei certification lab
<R1>
```

成功Telnet登录到R1。

步骤十一. 配置设备超级密码

在用户权限较低时（例如Telnet登陆时，可以定义权限级别为0或1），此时可以使用**super**命令进行权限提升。为避免非法权限提升带来的危害，应该配置超级密码进行防护。

为R1设置超级密码，密码以**simple**（明文）方式存储。

```
[R1]super password simple huawei
```

使用**display current-configuration**命令查看配置结果。

```
[R1]display current-configuration
……output omit……
#
 super password level 3 simple huawei
user-interface con 0
 authentication-mode password
……output omit……
```

如上所示，密码以明文存放，相对不安全。

为R2设置超级密码，密码以**cipher**（加密）方式存储。

```
[R2]super password cipher huawei
[R2]display current-configuration
```

```
……output omit……
#
 super password level 3 cipher Q;L]@C0S3[%;LEEP8+INFQ!!
user-interface con 0
 authentication-mode password
……output omit……
```

如上所示，密码以加密形式存放，相对安全。

步骤十二. 查看当前设备上存储的文件列表

在用户视图模式下使用**dir**命令查看当前目录下的文件列表。

```
<R1>dir
Directory of sd1:/

  Idx  Attr     Size(Byte)  Date        Time(LMT)  FileName
    0  -rw-      1,738,816  Sep 14 2011 11:50:24   web.zip
    1  -rw-     68,288,896  Jul 12 2011 14:17:58   ar2220_V200R001C01SPC300.cc

1,927,476 KB total (1,856,548 KB free)

<R2>dir
Directory of sd1:/

  Idx  Attr     Size(Byte)  Date        Time(LMT)  FileName
    0  -rw-      1,738,816  Sep 14 2011 11:50:58   web.zip
    1  -rw-     68,288,896  Jul 12 2011 14:19:02   ar2220_V200R001C01SPC300.cc

1,927,476 KB total (1,855,076 KB free)
```

步骤十三. 使用 FTP 功能在 R1 与 R2 之间上传和下载文件

本实验中R1作为FTP客户端，路由器默认即为FTP客户端；R2配置为FTP服务器。

在 R2上启用FTP服务器功能。

```
[R2]ftp server enable
Info: Succeeded in starting the FTP server
[R2]set default ftp-directory sd1:/
```

在R2上新建一个本地账户命名为“ftpuser”作为ftp登录账户。

```
[R2]aaa
[R2-aaa]local-user ftpuser password cipher huawei
[R2-aaa]local-user ftpuser service-type ftp
[R2-aaa]local-user ftpuser privilege level 15
```

尝试从R1用FTP工具登录到R2。

```
<R1>ftp 10.0.12.2
Trying 10.0.12.2 ...
Press CTRL+K to abort
Connected to 10.0.12.2.
220 FTP service ready.
User(10.0.12.2:(none)):ftpuser
331 Password required for ftpuser.
Enter password:
230 User logged in.

[R1-ftp]
```

此提示符表示已经成功登录到R2 FTP服务器。

将R1上的文件通过FTP的方式传送到R2。

```
[R1-ftp]put hq-r.cfg file-from-R1.bak
200 Port command okay.
150 Opening ASCII mode data connection for file-from-R1.bak.
226 Transfer complete.
FTP: 0 byte(s) sent in 0.627 second(s) 0.00byte(s)/sec.
[R1-ftp]
```

提示：在实际实验设备上源文件名可能不同，注意修改，请在R1用户视图模式下使用**dir**命令查看文件列表中的文件名。

使用**dir**命令查看传送结果。

```
[R1-ftp]dir
200 Port command okay.
150 Opening ASCII mode data connection for *.
-rwxrwxrwx   1 noone    nogroup   1738816 Sep 14 11:50 web.zip
-rwxrwxrwx   1 noone    nogroup  68288896 Jul 12 14:19
ar2220_V200R001C01SPC300.cc
-rwxrwxrwx   1 noone    nogroup         0 Sep 14 14:10 file-from-r1.bak
226 Transfer complete.
```

```
FTP: 551 byte(s) received in 0.619 second(s) 890.14byte(s)/sec.
```

以上列表显示的文件为R2 FTP服务器上的文件列表。

将文件“file-from-r1.bak”从R2下载到R1，并更名为“file-from-r2.bak”。

```
[R1-ftp]get file-from-r1.bak file-from-r2.bak
200 Port command okay.
150 Opening ASCII mode data connection for file-from-r1.bak.

226 Transfer complete.
FTP: 0 byte(s) received in 0.591 second(s) 0.00byte(s)/sec.
```

退出FTP服务器并查看R1上的文件列表，确认已成功下载的文件“file-from-r2.bak”。

```
 [R1-ftp]quit
221 Server closing.
<R1>dir
Directory of sd1:/

  Idx  Attr     Size(Byte)  Date        Time(LMT)  FileName
    0  -rw-      1,738,816  Sep 16 2011 18:44:54   web.zip
    1  -rw-     68,288,896  Jul 12 2011 14:17:58   ar2220_V200R001C01SPC300.cc
    2  -rw-              0  Sep 16 2011 19:13:00   file-from-r2.bak

1,927,476 KB total (1,856,548 KB free)
<R1>
```

删除设备上的文件。

- 警告：请注意只删除上面实验生成的两个文件“file-from-r1.bak”和“file-from-r2.bak”，请勿随便删除其它文件，否则可能导致设备不能正常运行！

删除R2上的文件“file-from-r1.bak”。

```
<R2>dir
Directory of sd1:/

  Idx  Attr     Size(Byte)  Date        Time(LMT)  FileName
    0  -rw-      1,738,816  Sep 14 2011 11:50:58   web.zip
    1  -rw-     68,288,896  Jul 12 2011 14:19:02   ar2220_V200R001C01SPC300.cc
    2  -rw-              0  Sep 14 2011 14:10:08   file-from-r1.bak

1,927,476 KB total (1,855,076 KB free)
```

```
<R2>delete /unreserved file-from-r1.bak
Warning: The contents of file sd1:/file-from-r1.bak cannot be recycled. Continue?
(y/n)[n]:y
Info: Deleting file sd1:/file-from-r1.bak...succeed.
```

“**/unreserved**”参数表示彻底删除该文件，不能恢复，请慎用。

```
<R2>dir
Directory of sd1:/

  Idx  Attr     Size(Byte)  Date        Time(LMT)  FileName
    0  -rw-      1,738,816  Sep 14 2011 11:50:58   web.zip
    1  -rw-     68,288,896  Jul 12 2011 14:19:02   ar2220_V200R001C01SPC300.cc

1,927,476 KB total (1,855,076 KB free)
```

对比之前的文件列表，确认文件“file-from-r1.bak”已删除。

删除R1上的文件file-from-r2.bak。

```
<R1>delete /unreserved file-from-r2.bak
Warning: The contents of file sd1:/file-from-r2.bak cannot be recycled. Continue?
(y/n)[n]:y
Info: Deleting file sd1:/file-from-r2.bak...succeed.
<R1>dir
Directory of sd1:/

  Idx  Attr     Size(Byte)  Date        Time(LMT)  FileName
    0  -rw-      1,738,816  Sep 16 2011 18:44:54   web.zip
    1  -rw-     68,288,896  Jul 12 2011 14:17:58   ar2220_V200R001C01SPC300.cc

1,927,476 KB total (1,856,548 KB free)
<R1>
```

步骤十四. 管理配置文件

保存当前配置文件。

```
<R1>save
  The current configuration will be written to the device.
  Are you sure to continue? (y/n)[n]:y
  It will take several minutes to save configuration file, please wait...........
  Configuration file had been saved successfully
```

```
  Note: The configuration file will take effect after being activated
```

显示已保存的配置信息。

```
<R1>display saved-configuration
 [V200R001C01SPC300]
#
 sysname R1
 header shell information "Welcome to Huawei certification lab"
#
 board add 0/1 1SA
 board add 0/2 1SA
……output omit……
```

显示当前生效的配置信息。

```
<R1>display current-configuration
 [V200R001C01SPC300]
#
 sysname R1
 header shell information "Welcome to Huawei certification lab"
#
 board add 0/1 1SA
 board add 0/2 1SA
 board add 0/3 2FE
……output omit……
```

路由器中可以存放多个配置文件。根据需要，我们可以设置路由器下次启动时使用的配置文件。

```
<R1>startup saved-configuration iascfg.zip
This operation will take several minutes, please wait.........
Info: Succeeded in setting the file for booting system
<R1>
```

使用如下命令确认下次启动使用的配置文件。

```
<R1>display startup
MainBoard:
  Startup system software:                sd1:/ar2220_V200R001C01SPC300.cc
  Next startup system software:            sd1:/ar2220_V200R001C01SPC300.cc
  Backup system software for next startup:   null
  Startup saved-configuration file:         null
  Next startup saved-configuration file:     sd1:/iascfg.zip
  Startup license file:                   null
```

```
  Next startup license file:              null
  Startup patch package:                 null
  Next startup patch package:             null
  Startup voice-files:                   null
  Next startup voice-files:               null
```

清除存储的配置文件。

```
<R1>reset saved-configuration
This will delete the configuration in the flash memory.
The device configurations will be erased to reconfigure.
Are you sure? (y/n)[n]:y
 Clear the configuration in the device successfully.
<R1>
```

步骤十五. 重启路由器

使用**reboot**命令重启路由器。

```
<R1>reboot
Info: The system is now comparing the configuration, please wait.
Warning: All the configuration will be saved to the next startup configuration.
Continue ? [y/n]:n
System will reboot! Continue ? [y/n]:y
Info: system is rebooting ,please wait...
```

系统会提示是否保存当前配置，请根据实验需要进行选择，如果不确定，请使用不要保存配置，进行重启。

附加实验：思考并验证

1、ARG3路由器支持通过USB接口进行配置管理。请使用USB线缆，参照产品说明书，进行配置操作。

2、现在的大部分笔记本电脑，没有COM接口，这时如何对设备进行配置？列举出你能想到的所有方法。

最终设备配置

```
[R1]display current-configuration
[V200R001C01SPC300]
#
```

```
 sysname R1
 tftp client-source -i Serial2/0/0
 header shell information "Welcome to Huawei certification lab"
#
voice
#
 http server enable
#
 drop illegal-mac alarm
#
 l2tp aging 0
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password simple admin
 local-user admin service-type http
#
interface Ethernet3/0/0
#
interface Ethernet3/0/1
#
interface Serial1/0/0
 link-protocol ppp
description This interface connect to R2-S2/0/0
 ip address 10.0.12.1 255.255.255.0
#
interface Serial2/0/0
 link-protocol ppp
#
interface GigabitEthernet0/0/0
#
interface GigabitEthernet0/0/1
#
interface GigabitEthernet0/0/2
#
interface Cellular0/0/0
 link-protocol ppp
#
interface Cellular0/0/1
```

```
 link-protocol ppp
#
interface NULL0
#
 super password level 3 simple huawei
user-interface con 0
 authentication-mode password
 set authentication password simple huawei
 idle-timeout 10 0
user-interface vty 0 4
 user privilege level 3
 set authentication password simple huawei
user-interface vty 16 20
#
return

[R2]display current-configuration
[V200R001C01SPC300]
#
 sysname R2
 ftp server enable
 set default ftp-directory sd1:/
#
 board add 0/1 1SA
 board add 0/2 1SA
 board add 0/3 2FE
#
voice
#
 http server enable
#
 drop illegal-mac alarm
#
 l2tp aging 0
#
 dhcp enable
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
```

```
 local-user admin password simple admin
 local-user admin service-type http
 local-user ftpuser password cipher N`C55QK<`=/Q=^Q`MAF4<1!!
 local-user ftpuser privilege level 15
 local-user ftpuser service-type ftp
 local-user huawei password simple huawei
 local-user huawei privilege level 15
 local-user huawei service-type telnet ftp
#
interface Ethernet3/0/0
#
interface Ethernet3/0/1
#
interface Serial1/0/0
 link-protocol ppp
description This interface connect to R1-S2/0/0
 ip address 10.0.12.2 255.255.255.0
#
interface Serial2/0/0
 link-protocol ppp
#
interface GigabitEthernet0/0/0
#
interface GigabitEthernet0/0/1
#
interface GigabitEthernet0/0/2
#
interface Cellular0/0/0
 link-protocol ppp
#
interface Cellular0/0/1
 link-protocol ppp
#
interface NULL0
#
 super password level 3 cipher Q;L]@C0S3[%;LEEP8+INFQ!!
user-interface con 0
user-interface vty 0 4
 authentication-mode aaa
user-interface vty 16 20
#
return
```

第二章 静态路由及默认路由

实验 2-1 静态路由及默认路由

学习目的

- 了解静态路由与默认路由相对于动态路由的优点
- 理解路由的作用以及路由操作的过程
- 掌握配置静态路由（下一跳为接口）的方法
- 掌握配置静态路由（下一跳为IP地址）的方法
- 掌握测试静态路由连通性的方法
- 掌握通过配置缺省路由实现末节网络与外部网络之间的访问
- 掌握测试缺省路由的方法
- 掌握在拥有冗余链路的路由器上配置静态备份路由
- 掌握测试静态备份路由的方法

拓扑图

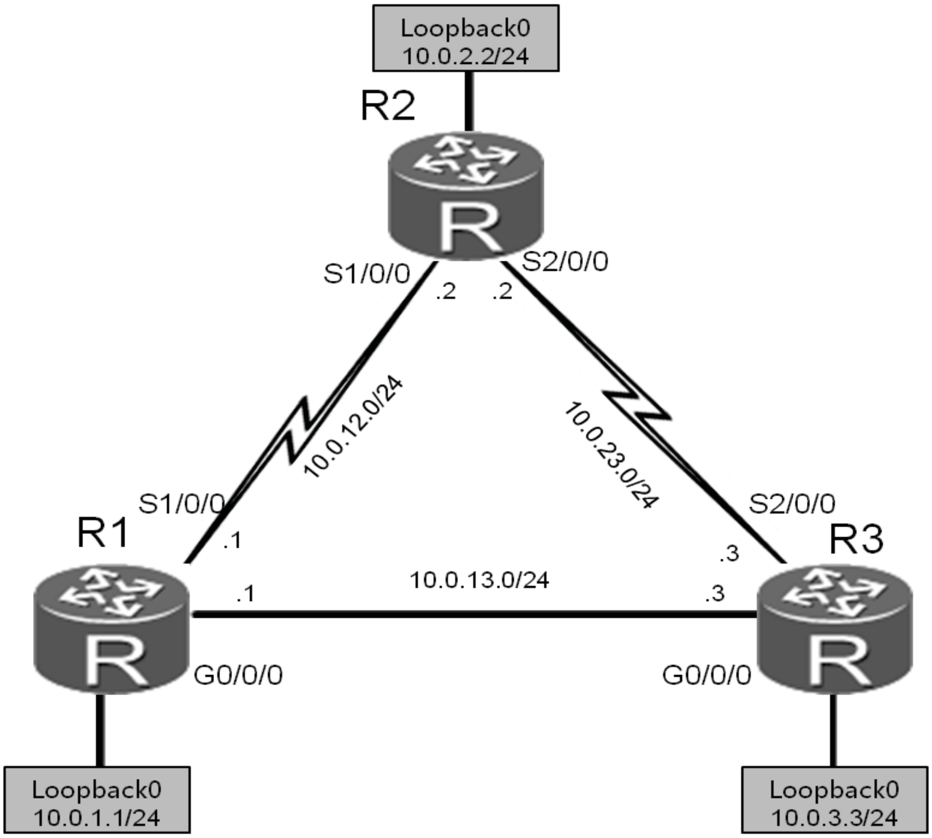


图2.1 静态路由及默认路由实验拓扑图

场景

你是你们公司的网络工程师，现在公司有一个总部和两个分支机构。其中R1为总部路由器，总部有一个网段，R2、R3为分支机构。R1通过以太网和串行线缆与分支机构相连，分支结构之间也通过串行线缆实现互联。

因为网络规模较小，所以采用静态路由和默认路由的方式实现网络互通。IP地址编址信息如拓扑图。

学习任务

步骤一. 基础配置与 IP 编址

配置R1、R2、R3的设备名称，配置IP地址。

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 24
[R1-Serial1/0/0]description this port connect to R2-S1/0/0
[R1-Serial1/0/0]quit
[R1]interface GigabitEthernet 0/0/0
[R1-GigabitEthernet0/0/0]ip address 10.0.13.1 24
[R1-GigabitEthernet0/0/0]description this port connect to R3-G0/0/0
[R1-GigabitEthernet0/0/0]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24
```

使用**display current-configuration**命令检查以上配置。

```
[R1-LoopBack0]display current-configuration
……output omit……
#
interface GigabitEthernet 0/0/0
 description this port connect to R3-G0/0/0
 ip address 10.0.13.1 255.255.255.0
#
interface Ethernet3/0/1
#
interface Serial1/0/0
 link-protocol ppp
 description this port connect to R2-S1/0/0
 ip address 10.0.12.1 255.255.255.0
#
……output omit……
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
……output omit……

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
```

```
[Huawei]sysname R2
[R2]interface serial 1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 24
[R2-Serial1/0/0]description this port connect to R1-S1/0/0
[R2-Serial1/0/0]interface serial 2/0/0
[R2-Serial2/0/0]ip address 10.0.23.2 24
[R2-Serial2/0/0]description this port connect to R3-S2/0/0
[R2-Serial2/0/0]interface loopback0
[R2-LoopBack0]ip address 10.0.2.2 24
[R2-LoopBack0]display current-configuration
……output omit……
interface Serial1/0/0
 link-protocol ppp
 description this port connect to R1-S1/0/0
 ip address 10.0.12.2 255.255.255.0
#
interface Serial2/0/0
 link-protocol ppp
 description this port connect to R3-S2/0/0
 ip address 10.0.23.2 255.255.255.0
#
……output omit……
#
interface LoopBack0
ip address 10.0.2.2 255.255.255.0

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface Serial 2/0/0
[R3-Serial2/0/0]ip address 10.0.23.3 24
[R3-Serial2/0/0]description this port connect to R2-S2/0/0
[R3-Serial2/0/0]quit
[R3]interface GigabitEthernet 0/0/0
[R3-GigabitEthernet0/0/0]ip address 10.0.13.3 24
[R3-GigabitEthernet0/0/0]description this port connect to R1-G0/0/0
[R3-GigabitEthernet0/0/0]interface loopback 0
[R3-LoopBack0]ip address 10.0.3.3 24
[R3-LoopBack0]display current-configuration
……output omit……
#
interface Serial2/0/0
 link-protocol ppp
```

```
 description this port connect to R2-S2/0/0
 ip address 10.0.23.3 255.255.255.0
#
interface GigabitEthernet0/0/0
 description this port connect to R1-G0/0/0
 ip address 10.0.13.3 255.255.255.0
#
……output omit……
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
……output omit……
```

完成配置后，测试网络连通性。

```
<R1>ping 10.0.12.2
  PING 10.0.12.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.12.2: bytes=56 Sequence=1 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=2 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=3 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=4 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=5 ttl=255 time=30 ms

  --- 10.0.12.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 30/30/30 ms

<R1>ping 10.0.13.3
  PING 10.0.13.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.13.3: bytes=56 Sequence=1 ttl=255 time=6 ms
    Reply from 10.0.13.3: bytes=56 Sequence=2 ttl=255 time=2 ms
    Reply from 10.0.13.3: bytes=56 Sequence=3 ttl=255 time=2 ms
    Reply from 10.0.13.3: bytes=56 Sequence=4 ttl=255 time=2 ms
    Reply from 10.0.13.3: bytes=56 Sequence=5 ttl=255 time=2 ms

  --- 10.0.13.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 2/2/6 ms

<R2>ping 10.0.23.3
```

```
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=255 time=31 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=255 time=31 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=255 time=41 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=255 time=31 ms
    Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=255 time=41 ms

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 31/35/41 ms
```

步骤二. 测试 R2 到目的网络 10.0.13.0/24、10.0.3.0/24 的连通性

```
[R2]ping 10.0.13.3
  PING 10.0.13.3: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.13.3 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss

[R2]ping 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss
```

此时R2如果要与网络10.0.3.0网段通讯，则需要R2上有去往该网段的路由信息，并且R3上也需要有回到R2接口IP网段的路由信息。

以上测试结果显示R2无法与地址10.0.3.3和10.0.13.3地址通讯。使用**display ip routing-table**命令查看R2的路由表，发现R2的路由表里面没有去往这两个网络的路由信息。

```
[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 15      Routes : 15

Destination/Mask    Proto   Pre  Cost     Flags NextHop       Interface

      10.0.2.0/24  Direct  0    0    D   10.0.2.2       LoopBack0
      10.0.2.2/32  Direct  0    0    D   127.0.0.1      InLoopBack0
    10.0.2.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.12.0/24  Direct  0    0    D   10.0.12.2      Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   10.0.12.1      Serial1/0/0
     10.0.12.2/32  Direct  0    0    D   127.0.0.1      InLoopBack0
   10.0.12.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.23.0/24  Direct  0    0    D   10.0.23.2      Serial2/0/0
     10.0.23.2/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.23.3/32  Direct  0    0    D   10.0.23.3      Serial2/0/0
   10.0.23.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     127.0.0.0/8   Direct  0    0    D   127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
255.255.255.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
```

步骤三. 在 R2 上配置静态路由

配置目的网络10.0.13.0/24和10.0.3.0/24的静态路由，下一跳信息设置为R3的接口地址10.0.23.3，默认静态路由优先级为60，无需额外配置路由优先级信息。

```
<R2>system-view
Enter system view, return user view with Ctrl+Z.
[R2]ip route-static 10.0.13.0 24 10.0.23.3
[R2]ip route-static 10.0.3.0 24 10.0.23.3
```

以上**ip route-static**命令中的24代表目的网络掩码长度，也可以写成完整的掩码形式如255.255.255.0。

步骤四.　配置备用静态路由

现在R2与地址10.0.13.3以及10.0.3.3通信时，数据通过R2与R3之间的链路进行发送。如果R2与R3之间的链路出现了故障，则通信将无法进行。

但是从拓扑图可以看出，在R2与R3之间的链路故障后，R2与R3之间的通信可以通过R1进行。我们可以配置备用静态路由，在网络正常的情况下，备用静态路由不起作用，但当R2与R3之间的链路出现故障时，备用静态路由将起作用，进行数据转发。

配置备用静态路由时，需要额外配置优先级信息，以便于只有在主链路失败时才使用备份链路。这里我们将备用的路由优先级定义为80。

```
[R1]ip route-static 10.0.3.0 24 10.0.13.3

[R2]ip route-static 10.0.13.0 255.255.255.0 Serial 1/0/0 preference 80
[R2]ip route-static 10.0.3.0 24 Serial 1/0/0 preference 80

[R3]ip route-static 10.0.12.0 24 10.0.13.1
```

步骤五.　验证静态路由

查看R2的路由表信息。

```
[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 17      Routes : 17

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.2.0/24  Direct  0    0    D   10.0.2.2       LoopBack0
      10.0.2.2/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    10.0.2.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
      10.0.3.0/24  Static  60   0    RD   10.0.23.3       Serial2/0/0
     10.0.12.0/24  Direct  0    0    D   10.0.12.2       Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   10.0.12.1       Serial1/0/0
     10.0.12.2/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   10.0.12.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
```

```
      10.0.13.0/24  Static  60   0    RD   10.0.23.3       Serial2/0/0
      10.0.23.0/24  Direct  0    0    D   10.0.23.2       Serial2/0/0
      10.0.23.2/32  Direct  0    0    D   127.0.0.1       InLoopBack0
      10.0.23.3/32  Direct  0    0    D   10.0.23.3       Serial2/0/0
    10.0.23.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
      127.0.0.0/8   Direct  0    0    D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
```

以上路由表中显示了两条我们刚才配置的静态路由，Proto字段为Static表示静态路由。Pre字段的数字60代表静态路由的默认优先级。

在R2与R3之间链路正常时，测试网络的连通。

```
[R2]ping 10.0.13.3
  PING 10.0.13.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.13.3: bytes=56 Sequence=1 ttl=255 time=34 ms
    Reply from 10.0.13.3: bytes=56 Sequence=2 ttl=255 time=34 ms
    Reply from 10.0.13.3: bytes=56 Sequence=3 ttl=255 time=34 ms
    Reply from 10.0.13.3: bytes=56 Sequence=4 ttl=255 time=34 ms
    Reply from 10.0.13.3: bytes=56 Sequence=5 ttl=255 time=34 ms

  --- 10.0.13.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 34/34/34 ms

[R2]ping 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=255 time=41 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=255 time=41 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=255 time=41 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=255 time=41 ms
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=255 time=41 ms

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 41/41/41 ms
```

显示通信正常。

同时可以使用**tracert**命令查看数据发送时，数据包所经过的路由器。

```
<R2>tracert 10.0.13.3
 traceroute to  10.0.13.3(10.0.13.3), max hops: 30 ,packet length: 40,
 press CTRL_C to break
 1 10.0.23.3 40 ms  31 ms  30 ms

<R2>tracert 10.0.3.3
 traceroute to  10.0.3.3(10.0.3.3), max hops: 30 ,packet length: 40,
 press CTRL_C to break
 1 10.0.23.3 40 ms  30 ms  30 ms
```

如命令显示，R2将数据直接发送给R3，未经过其他设备。

步骤六.　验证备用静态路由

关闭R2的Serial2/0/0接口，并观察三台路由器的路由表变化。

此时，注意与关闭接口之前的路由表情况作对比。

```
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]shutdown
[R2-Serial2/0/0]quit
[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 13      Routes : 13

Destination/Mask    Proto   Pre  Cost     Flags NextHop       Interface


      10.0.2.0/24  Direct  0    0    D   10.0.2.2       LoopBack0
      10.0.2.2/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    10.0.2.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
      10.0.3.0/24  Static  80   0    D   10.0.12.2       Serial1/0/0
     10.0.12.0/24  Direct  0    0    D   10.0.12.2       Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   10.0.12.1       Serial1/0/0
     10.0.12.2/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   10.0.12.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.13.0/24  Static  80   0    D   10.0.12.2       Serial1/0/0
     127.0.0.0/8   Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
```

```
255.255.255.255/32  Direct  0    0   D   127.0.0.1       InLoopBack0
```

注意观察标识出来的两条路由。它们的下一跳及优先级信息已经发生更改。

在R2上测试与目标地址10.0.13.3和10.0.3.3的连通性。

```
<R2>ping 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=255 time=3 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=255 time=2 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=255 time=2 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=255 time=2 ms
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=255 time=2 ms

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 2/2/3 ms

<R2>ping 10.0.13.3
  PING 10.0.13.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.13.3: bytes=56 Sequence=1 ttl=255 time=3 ms
    Reply from 10.0.13.3: bytes=56 Sequence=2 ttl=255 time=2 ms
    Reply from 10.0.13.3: bytes=56 Sequence=3 ttl=255 time=2 ms
    Reply from 10.0.13.3: bytes=56 Sequence=4 ttl=255 time=2 ms
    Reply from 10.0.13.3: bytes=56 Sequence=5 ttl=255 time=2 ms

  --- 10.0.13.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 2/2/3 ms
```

网络未因为R2与R3之间的链路被关闭而中断。

同样这里也可以使用**tracert**命令，查看数据发送时，数据包传输所经过的路由器。

```
<R2>tracert 10.0.13.3
 traceroute to  10.0.13.3(10.0.13.3), max hops: 30 ,packet length: 40,press CTRL_C to break
 1 10.0.12.1 40 ms  21 ms  21 ms
 2 10.0.13.3 30 ms  21 ms  21 ms
```

```
<R2>tracert 10.0.3.3
 traceroute to  10.0.3.3(10.0.3.3), max hops: 30 ,packet length: 40,press CTRL_C
to break
 1 10.0.12.1 40 ms  21 ms  21 ms
 2 10.0.13.3 30 ms  21 ms  21 ms
```

从**tracert**命令得到的信息看，R2发送的数据经过R1抵达R3设备。

步骤七. 在 R1 上配置缺省路由实现网络互通

在R2设备上打开步骤六中关闭的接口。

```
[R2]int Serial 2/0/0
[R2-Serial2/0/0]undo shutdown
```

测试R1到R3的连通性。

```
[R1]ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss
```

原因在于R1缺少到达地址10.0.23.3的路由信息。

可以在R1上定义默认路由，实现网络通信。

```
[R1]ip route-static 0.0.0.0 0.0.0.0 10.0.13.3
```

配置完成后，测试R1与10.0.23.3之间的连通性。

```
[R1]ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=255 time=3 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=255 time=2 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=255 time=2 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=255 time=2 ms
```

```
   Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=255 time=2 ms

  --- 10.0.23.3 ping statistics ---
   5 packet(s) transmitted
   5 packet(s) received
   0.00% packet loss
round-trip min/avg/max = 2/2/3 ms
```

步骤八. 备用默认路由配置

同时如果R1与R3之间的链路出现故障，R1也可以通过R2与地址10.0.23.3以及10.0.3.3通信。

但是默认情况下R1不知道这条路径的存在。考虑在步骤四中配置备用静态路由，本步骤也可以配置备用默认路由。

```
[R1]ip route-static 0.0.0.0 0.0.0.0 10.0.12.2 preference 80

[R3]ip route-static 10.0.12.0 24 10.0.23.2 preference 80
```

步骤九. 验证备用默认路由

首先查看在链路正常的情况下，R1的路由条目。

```
<R1>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 16      Routes : 16

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

       0.0.0.0/0   Static  60   0    RD   10.0.13.3      GigabitEthernet0/0/0
      10.0.1.0/24  Direct  0    0    D   10.0.1.1       LoopBack0
      10.0.1.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
    10.0.1.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
      10.0.3.0/24  Static  60   0    RD   10.0.13.3      GigabitEthernet0/0/0
     10.0.12.0/24  Direct  0    0    D   10.0.12.1      Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.12.2/32  Direct  0    0    D   10.0.12.2      Serial1/0/0
   10.0.12.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.13.0/24  Direct  0    0    D   10.0.13.1      GigabitEthernet0/0/0
```

```
     10.0.13.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   10.0.13.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
      127.0.0.0/8  Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
```

关闭R1和R3的GigabitEthernet0/0/0接口，并查看R1路由条目，此时也应对照关闭接口前后路由条目的变化情况。

```
[R1]interface GigabitEthernet0/0/0
[R1-GigabitEthernet0/0/0]shutdown
[R1-GigabitEthernet0/0/0]quit

[R3]interface GigabitEthernet0/0/0
[R3-GigabitEthernet0/0/0]shutdown
[R3-GigabitEthernet0/0/0]quit

[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 12      Routes : 12

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

        0.0.0.0/0   Static  80   0     RD   10.0.12.2       Serial1/0/0
      10.0.1.0/24  Direct  0    0    D   10.0.1.1        LoopBack0
      10.0.1.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    10.0.1.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.12.0/24  Direct  0    0    D   10.0.12.1       Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.12.2/32  Direct  0    0    D   10.0.12.2       Serial1/0/0
   10.0.12.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
      127.0.0.0/8  Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
```

从上面路由表中可以看出，0.0.0.0默认路由的Preference值为80，即备用默认路由已生效。

在R1上测试网络连通情况。

```
[R1]ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=254 time=76 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=254 time=250 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=254 time=76 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=254 time=76 ms
    Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=254 time=76 ms

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 76/110/250 ms
[R1]tracert 10.0.23.3
 traceroute to  10.0.23.3(10.0.23.2), max hops: 30 ,packet length: 40,press CTRL_C
to break
 1 10.0.12.2 30 ms  26 ms  26 ms
 2 10.0.23.3 60 ms  53 ms  56 ms
```

显示数据包经过R2抵达R3设备。

附加实验：思考并验证

我们可以使用扩展**ping**命令，控制发送数据包的其他信息，例如源地址、数据包大小、数据包数量等。请思考:

1、默认情况下，路由器发出的**ping**数据报，源地址为多少？

2、本实验中，是否所有网段都已经可以互通？如果不是，请指出，并展示出来？

3、对于本次实验的拓扑图，如果单独仅从配置静态路由实现互通的角度看，如何配置才是完整的并且最简介的静态路由配置？

4、配置静态路由时，可以使用参数“下一跳的IP地址”，也可以使用参数“接口标识”，思考这两种配置的差异。有余力的同学，考虑其他厂商在实现静态路由配置时是如何定义的？这种差异会导致问题出现吗？

附录 A：华为路由器各路由协议的默认优先级

路由协议或路由种类	优先级
Direct	0
OSPF	10
IS-IS	15
Static	60
RIP	100
OSPF ASE	150
BGP	255

最终设备配置

```
<R1>display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
interface Serial1/0/0
 link-protocol ppp
 description this port connect to R2-S1/0/0
 ip address 10.0.12.1 255.255.255.0
#
interface GigabitEthernet0/0/0
description this port connect to R3-G0/0/0
ip address 10.0.13.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.13.3
 ip route-static 0.0.0.0 0.0.0.0 10.0.12.2 preference 80
 ip route-static 10.0.3.0 255.255.255.0 10.0.13.3
#
return
```

```
<R2>display current-configuration
[V200R001C01SPC300]
#
 sysname R2
#
interface Serial1/0/0
 link-protocol ppp
 description this port connect to R1-S1/0/0
 ip address 10.0.12.2 255.255.255.0
#
interface Serial2/0/0
 link-protocol ppp
 description this port connect to R3-S2/0/0
 ip address 10.0.23.2 255.255.255.0
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
 ip route-static 10.0.3.0 255.255.255.0 10.0.23.3
 ip route-static 10.0.3.0 255.255.255.0 Serial1/0/0 preference 80
 ip route-static 10.0.13.0 255.255.255.0 10.0.23.3
 ip route-static 10.0.13.0 255.255.255.0 Serial1/0/0 preference 80
#
return

<R3>display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
interface Serial2/0/0
 link-protocol ppp
 description this port connect to R2-S2/0/0
 ip address 10.0.23.3 255.255.255.0
#
interface GigabitEthernet0/0/0
 description this port connect to R1-G0/0/0
 ip address 10.0.13.3 255.255.255.0
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
```

```
 ip route-static 10.0.12.0 255.255.255.0 10.0.13.1
 ip route-static 10.0.12.0 255.255.255.0 10.0.23.2 preference 80
#
return
```

第三章 RIP的配置

实验 3-1 RIPv1&v2 配置

学习目的

- 了解RIP路由协议防止环路的机制
- 理解RIP路由协议交换路由协议的方法
- 掌握配置RIPv1的方法
- 掌握在特定网络和接口上启用RIP的方法
- 掌握使用**display**与**debug**命令测试RIP的方法
- 掌握测试RIP路由网络的连通性
- 理解RIP发送和接收的网络前缀的形式
- 掌握配置RIPv2的方法
- 理解RIPv1与RIPv2的不同之处
- 掌握导入静态路由到RIP的方法

拓扑图

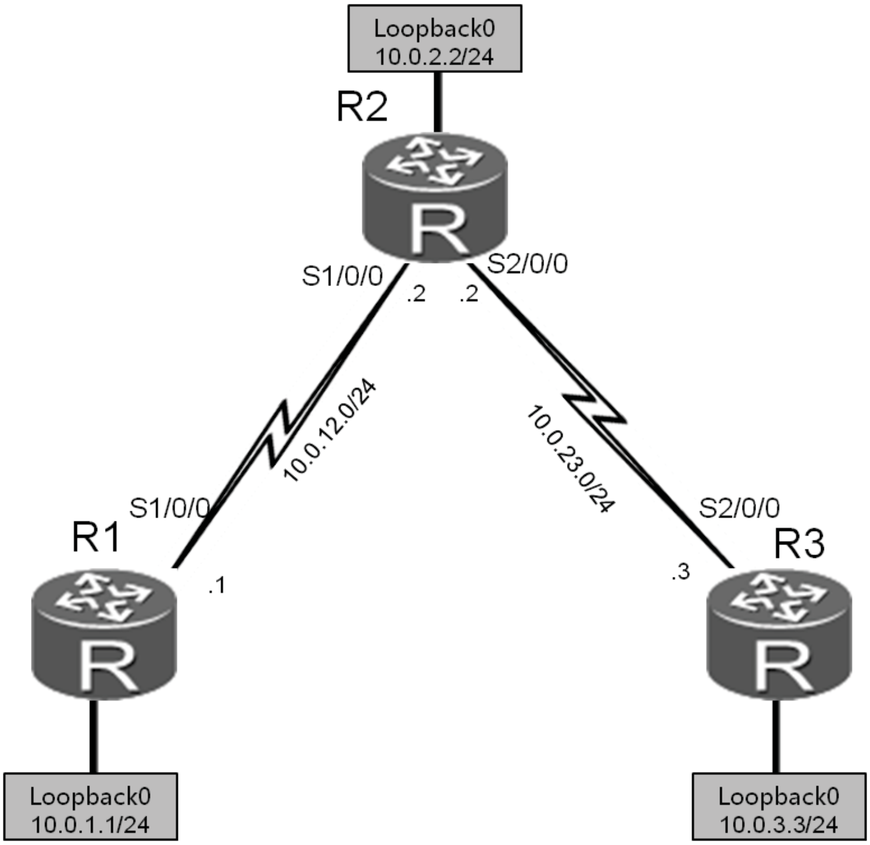


图3.1 RIPv1&v2实验拓扑图

场景

你是你们公司的网络管理员。现在公司的内部网较小，仅有三台路由器，规划了五个网络。所以你决定使用RIP协议来实现路由信息的相互传输。考虑到兼容性问题，你希望使用RIPv1，但是RIPv2有很多优点。经过测试，你最终使用了RIPv2。

学习任务

步骤一. 基本配置与 IP 编址

配置设备基本信息。参照拓扑图进行IP地址配置。

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 24
[R1-Serial1/0/0]description this port connect to R2-S1/0/0
[R1-Serial1/0/0]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24
[R1-LoopBack0]quit
```

使用**display current-configuration**命令检查以上配置。

```
[R1-LoopBack0]display current-configuration
……output omit……
#
interface Serial1/0/0
 link-protocol ppp
 description this port connect to R2-S1/0/0
 ip address 10.0.12.1 255.255.255.0
#
……output omit……
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
……output omit……

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface serial 1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 24
[R2-Serial1/0/0]description this port connect to R1-S1/0/0
[R2-Serial1/0/0]interface serial 2/0/0
[R2-Serial2/0/0]ip address 10.0.23.2 24
[R2-Serial2/0/0]description this port connect to R3-S2/0/0
[R2-Serial2/0/0]interface loopback0
[R2-LoopBack0]ip address 10.0.2.2 24
```

```
[R2-LoopBack0]display current-configuration

……output omit……
#
interface Serial1/0/0
 link-protocol ppp
 description this port connect to R1-S1/0/0
 ip address 10.0.12.2 255.255.255.0
#
interface Serial2/0/0
 link-protocol ppp
 description this port connect to R3-S2/0/0
 ip address 10.0.23.2 255.255.255.0
#
……output omit……
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface Serial 2/0/0
[R3-Serial2/0/0]ip address 10.0.23.3 24
[R3-Serial2/0/0]description this port connect to R2-S2/0/0
[R3-Serial2/0/0]interface loopback0
[R3-LoopBack0]ip address 10.0.3.3 24
[R3-LoopBack0]display current-configuration

……output omit……
#
interface Serial2/0/0
 link-protocol ppp
 description this port connect to R2-S2/0/0
 ip address 10.0.23.3 255.255.255.0
#
……output omit……
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
……output omit……
```

R1与R2可以相互通信。

```
<R1>ping 10.0.12.2
  PING 10.0.12.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.12.2: bytes=56 Sequence=1 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=2 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=3 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=4 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=5 ttl=255 time=30 ms

  --- 10.0.12.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 30/30/30 ms
```

R2能成功与R3的IP地址10.0.23.3通讯。

```
<R2>ping 10.0.23.3
  PING 10.0.23.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=255 time=31 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=255 time=31 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=255 time=41 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=255 time=31 ms
    Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=255 time=41 ms

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 31/35/41 ms
```

步骤二. RIPv1 协议配置

在R1上启动RIP协议，并将10.0.0.0网段通告到RIP协议。

```
[R1]rip 1
[R1-rip-1]network 10.0.0.0
```

在R2上启动RIP协议，并将10.0.0.0网段通告到RIP协议。

```
[R2]rip 1
[R2-rip-1]network 10.0.0.0
```

在R3上启动RIP协议，并将10.0.0.0这个网段通告到RIP协议。

```
[R3]rip 1
[R3-rip-1]net 10.0.0.0
```

步骤三. RIPv1 路由验证

查看R1、R2和R3的路由表，确认各路由器已经学习到以下灰色突出显示部分的RIP路由。

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 14      Routes : 14

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.1.0/24  Direct  0    0           D   10.0.1.1        LoopBack0
      10.0.1.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.1.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.2.0/24  RIP     100  1           D   10.0.12.2       Serial1/0/0
      10.0.3.0/24  RIP     100  2           D   10.0.12.2       Serial1/0/0
     10.0.12.0/24  Direct  0    0           D   10.0.12.1       Serial1/0/0
     10.0.12.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.12.2/32  Direct  0    0           D   10.0.12.2       Serial1/0/0
   10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.23.0/24  RIP     100  1           D   10.0.12.2       Serial1/0/0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0

[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 17      Routes : 17

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.1.0/24  RIP     100  1           D   10.0.12.1       Serial1/0/0
      10.0.2.0/24  Direct  0    0           D   10.0.2.2        LoopBack0
```

```
     10.0.2.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.2.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.3.0/24  RIP     100  1           D   10.0.23.3       Serial2/0/0
    10.0.12.0/24  Direct  0    0           D   10.0.12.2       Serial1/0/0
    10.0.12.1/32  Direct  0    0           D   10.0.12.1       Serial1/0/0
    10.0.12.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
  10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.23.0/24  Direct  0    0           D   10.0.23.2       Serial2/0/0
    10.0.23.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.23.3/32  Direct  0    0           D   10.0.23.3       Serial2/0/0
  10.0.23.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
    127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0

[R3]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 14      Routes : 14

Destination/Mask    Proto  Pre  Cost      Flags NextHop         Interface

     10.0.1.0/24  RIP     100  2           D   10.0.23.2       Serial2/0/0
     10.0.2.0/24  RIP     100  1           D   10.0.23.2       Serial2/0/0
     10.0.3.0/24  Direct  0    0           D   10.0.3.3        LoopBack0
     10.0.3.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
   10.0.3.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.12.0/24  RIP     100  1           D   10.0.23.2       Serial2/0/0
    10.0.23.0/24  Direct  0    0           D   10.0.23.3       Serial2/0/0
    10.0.23.2/32  Direct  0    0           D   10.0.23.2       Serial2/0/0
    10.0.23.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
  10.0.23.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
    127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

测试R1到10.0.23.3的连通性。R1与R3能够实现互通。

```
[R1]ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=254 time=70 ms
```

```
  Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=254 time=65 ms
  Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=254 time=65 ms
  Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=254 time=65 ms
  Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=254 time=65 ms

 --- 10.0.23.3 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 65/66/70 ms
```

使用**debug**命令查看RIP协议定期更新情况。

使用**debug**命令开启RIP调试功能。请注意，**debug**命令需要在用户视图下才能使用。并使用**terminal debugging**和 **terminal monitor**命令开启**debug**信息在屏幕上显示的功能。然后会看到电脑屏幕上显示出许多关于路由器之间RIP协议交互的信息。

```
<R1>debug rip 1
<R1>terminal debugging
Info: Current terminal debugging is on.
<R1>terminal monitor
Info: Current terminal monitor is on.
Sep 19 2011 19:15:22.630.1+00:00 R1 RM/6/RMDEBUG: 6: 11647: RIP 1: Receiving v1 response on Serial1/0/0 from 10.0.12.2 with 2 RTEs
Sep 19 2011 19:15:22.630.2+00:00 R1 RM/6/RMDEBUG: 6: 11698: RIP 1: Receive response from 10.0.12.2 on Serial1/0/0
Sep 19 2011 19:15:22.630.3+00:00 R1 RM/6/RMDEBUG: 6: 11709: Packet: Version 1, Cmd response, Length 44
Sep 19 2011 19:15:22.630.4+00:00 R1 RM/6/RMDEBUG: 6: 11758: Dest 10.0.3.0, Cost 2
Sep 19 2011 19:15:22.630.5+00:00 R1 RM/6/RMDEBUG: 6: 11758: Dest 10.0.23.0, Cost 1
Sep 19 2011 19:15:52.650.1+00:00 R1 RM/6/RMDEBUG: 6: 11647: RIP 1: Receiving v1 response on Serial1/0/0 from 10.0.12.2 with 2 RTEs
Sep 19 2011 19:15:52.650.2+00:00 R1 RM/6/RMDEBUG: 6: 11698: RIP 1: Receive response from 10.0.12.2 on Serial1/0/0
Sep 19 2011 19:15:52.650.3+00:00 R1 RM/6/RMDEBUG: 6: 11709: Packet: Version 1, Cmd response, Length 44
Sep 19 2011 19:15:52.650.4+00:00 R1 RM/6/RMDEBUG: 6: 11758: Dest 10.0.2.0, Cost 1
```

可以使用**undo debug rip**或者**undo debug all**命令关闭**debug**调试功能。

```
<R1>undo debug rip 1
```

也可以使用带更多参数的命令查看某类型的调试信息，如**debug rip 1 event**查看路由器发出和收到的定期更新事件。其它参数可以使用“？”获取帮助。

```
<R1>debug rip 1 event
Sep 19 2011 19:23:44.200.1+00:00 R1 RM/6/RMDEBUG: 25: 3873: RIP 1: Periodic timer expired for interface Serial1/0/0 (10.0.12.1) and its added to periodic update queue
Sep 19 2011 19:23:44.210.1+00:00 R1 RM/6/RMDEBUG: 25: 4201: RIP 1: Interface Serial1/0/0 (10.0.12.1) is deleted from the periodic update queue
<R1>undo debug all
Info: All possible debugging has been turned off
```

警告：开启过多的**debug**功能会耗费大量路由器资源，甚至可能导致宕机。请慎重使用开启批量**debug**功能的命令，如**debug all**。

步骤四. RIPv2 协议配置

基于前面的配置，只需在RIP子视图模式下配置**version 2**即可。

```
[R1]rip 1
[R1-rip-1]version 2

[R2]rip 1
[R2-rip-1]version 2

[R3]rip 1
[R3-rip-1]version 2
```

步骤五. RIPv2 路由验证

查看R1、R2和R3的路由表。

使用**display ip routing-table**命令查看各路由器路由表，注意比较灰色突出显示部分路由条目与之前RIPv1的不同之处。

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 14      Routes : 14

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface
```

```
       10.0.1.0/24  Direct  0    0           D   10.0.1.1        LoopBack0
       10.0.1.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.1.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
       10.0.2.0/24  RIP     100  1           D   10.0.12.2       Serial1/0/0
       10.0.3.0/24  RIP     100  2           D   10.0.12.2       Serial1/0/0
      10.0.12.0/24  Direct  0    0           D   10.0.12.1       Serial1/0/0
      10.0.12.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.12.2/32  Direct  0    0           D   10.0.12.2       Serial1/0/0
    10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.23.0/24  RIP     100  1           D   10.0.12.2       Serial1/0/0
      127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0

[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 17       Routes : 17

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

       10.0.1.0/24  RIP     100  1           D   10.0.12.1       Serial1/0/0
       10.0.2.0/24  Direct  0    0           D   10.0.2.2        LoopBack0
       10.0.2.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.2.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
       10.0.3.0/24  RIP     100  1           D   10.0.23.3       Serial2/0/0
      10.0.12.0/24  Direct  0    0           D   10.0.12.2       Serial1/0/0
      10.0.12.1/32  Direct  0    0           D   10.0.12.1       Serial1/0/0
      10.0.12.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.23.0/24  Direct  0    0           D   10.0.23.2       Serial2/0/0
      10.0.23.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.23.3/32  Direct  0    0           D   10.0.23.3       Serial2/0/0
    10.0.23.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0

[R3]display ip routing-table
Route Flags: R - relay, D - download to fib
```

```
----------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 14      Routes : 14

Destination/Mask    Proto   Pre  Cost      Flags NextHop        Interface

      10.0.1.0/24  RIP     100  2           D   10.0.23.2       Serial2/0/0
      10.0.2.0/24  RIP     100  1           D   10.0.23.2       Serial2/0/0
      10.0.3.0/24  Direct  0    0           D   10.0.3.3        LoopBack0
      10.0.3.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.3.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.12.0/24  RIP     100  1           D   10.0.23.2       Serial2/0/0
     10.0.23.0/24  Direct  0    0           D   10.0.23.3       Serial2/0/0
     10.0.23.2/32  Direct  0    0           D   10.0.23.2       Serial2/0/0
     10.0.23.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
   10.0.23.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

请注意，在使用RIPv1协议时，路由学习情况与使用RIPv2协议时路由学习情况一样。思考是什么原因导致的？

测试R1到10.0.23.3的连通性。

```
[R1]ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=254 time=74 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=254 time=75 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=254 time=75 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=254 time=75 ms
    Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=254 time=75 ms

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 74/74/75 ms
```

使用**debug**命令查看RIPv2协议定期更新情况。

```
<R1>terminal debugging
Info: Current terminal debugging is on.
<R1>terminal monitor
```

```
Info: Current terminal monitor is on.
<R1>debug rip 1 event
Sep 19 2011 19:55:46.600.1+00:00 R1 RM/6/RMDEBUG: 25: 3873: RIP 1: Periodic timer expired for interface Serial1/0/0 (10.0.12.1) and its added to periodic update queue
Sep 19 2011 19:55:46.610.1+00:00 R1 RM/6/RMDEBUG: 25: 4201: RIP 1: Interface Serial1/0/0 (10.0.12.1) is deleted from the periodic update queue
<R1>undo debug rip 1
<R1>debug rip 1 packet
Sep 19 2011 20:31:34.230.1+00:00 R1 RM/6/RMDEBUG: 6: 11689: RIP 1: Sending response on interface Serial1/0/0 from 10.0.12.1 to 224.0.0.9
Sep 19 2011 20:31:34.230.2+00:00 R1 RM/6/RMDEBUG: 6: 11709: Packet: Version 2, Cmd response, Length 24
Sep 19 2011 20:31:34.230.3+00:00 R1 RM/6/RMDEBUG: 6: 11777: Dest 10.0.1.0/24, Nexthop 0.0.0.0, Cost 1, Tag 0
<R1>undo debug all
Info: All possible debugging has been turned off
```

步骤六. RIPv2 静态路由引入配置

本步骤中，我们将在R3上添加一个Loopback口，配置IP地址为172.16.3.3/24，然后在R2上配置到达该网段的路由。并将此静态路由引入到RIP路由信息中，以便实现R1与172.16.3.3地址之间的通讯。

R3配置Loopback接口。

```
[R3]interface LoopBack 1
[R3-LoopBack1]ip address 172.16.3.3 24
```

测试R1到172.16.3.3的连通性。

```
[R1]ping 172.16.3.3
  PING 172.16.3.3: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 172.16.3.3 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss
```

此时R1没有去往172.16.3.3的路由，所以无法通讯。

在R2上配置静态路由。

```
<R2>system-view
[R2]ip route-static 172.16.3.0 24 10.0.23.3
```

将静态路由引入RIPv2路由协议。

```
[R2]rip 1
[R2-rip-1]import-route static
```

步骤七. RIPv2 静态路由引入验证

查看R1、R2和R3的路由表，发现R1里面出现了去往172.16.3.0/24的路由；R2里面多出了配置的去往172.16.3.0/24的静态路由；R3的路由表则无变化。

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 15      Routes : 15

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.1.0/24  Direct  0    0           D   10.0.1.1        LoopBack0
      10.0.1.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.1.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.2.0/24  RIP     100  1           D   10.0.12.2       Serial1/0/0
      10.0.3.0/24  RIP     100  2           D   10.0.12.2       Serial1/0/0
     10.0.12.0/24  Direct  0    0           D   10.0.12.1       Serial1/0/0
     10.0.12.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.12.2/32  Direct  0    0           D   10.0.12.2       Serial1/0/0
   10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.23.0/24  RIP     100  1           D   10.0.12.2       Serial1/0/0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    172.16.3.0/24  RIP     100  1           D   10.0.12.2       Serial1/0/0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0

[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
```

```
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 18      Routes : 18

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

      10.0.1.0/24  RIP     100  1          D   10.0.12.1      Serial1/0/0
      10.0.2.0/24  Direct  0    0          D   10.0.2.2       LoopBack0
      10.0.2.2/32  Direct  0    0          D   127.0.0.1      InLoopBack0
    10.0.2.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
      10.0.3.0/24  RIP     100  1          D   10.0.23.3      Serial2/0/0
     10.0.12.0/24  Direct  0    0          D   10.0.12.2      Serial1/0/0
     10.0.12.1/32  Direct  0    0          D   10.0.12.1      Serial1/0/0
     10.0.12.2/32  Direct  0    0          D   127.0.0.1      InLoopBack0
   10.0.12.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
     10.0.23.0/24  Direct  0    0          D   10.0.23.2      Serial2/0/0
     10.0.23.2/32  Direct  0    0          D   127.0.0.1      InLoopBack0
     10.0.23.3/32  Direct  0    0          D   10.0.23.3      Serial2/0/0
   10.0.23.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
     127.0.0.0/8   Direct  0    0          D   127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
    172.16.3.0/24  Static  60   0          RD  10.0.23.3      Serial2/0/0
255.255.255.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0

[R3]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 17      Routes : 17

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

      10.0.1.0/24  RIP     100  2          D   10.0.23.2      Serial2/0/0
      10.0.2.0/24  RIP     100  1          D   10.0.23.2      Serial2/0/0
      10.0.3.0/24  Direct  0    0          D   10.0.3.3       LoopBack0
      10.0.3.3/32  Direct  0    0          D   127.0.0.1      InLoopBack0
    10.0.3.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
     10.0.12.0/24  RIP     100  1          D   10.0.23.2      Serial2/0/0
     10.0.23.0/24  Direct  0    0          D   10.0.23.3      Serial2/0/0
     10.0.23.2/32  Direct  0    0          D   10.0.23.2      Serial2/0/0
     10.0.23.3/32  Direct  0    0          D   127.0.0.1      InLoopBack0
   10.0.23.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
```

```
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    172.16.3.0/24  Direct  0    0           D   172.16.3.3      LoopBack1
    172.16.3.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
  172.16.3.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

测试R1到172.16.3.3的连通性。

R1可以与172.16.3.3通信。

```
[R1]ping 172.16.3.3
  PING 172.16.3.3: 56  data bytes, press CTRL_C to break
    Reply from 172.16.3.3: bytes=56 Sequence=1 ttl=254 time=63 ms
    Reply from 172.16.3.3: bytes=56 Sequence=2 ttl=254 time=73 ms
    Reply from 172.16.3.3: bytes=56 Sequence=3 ttl=254 time=74 ms
    Reply from 172.16.3.3: bytes=56 Sequence=4 ttl=254 time=65 ms
    Reply from 172.16.3.3: bytes=56 Sequence=5 ttl=254 time=74 ms

  --- 172.16.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 63/69/74 ms
```

附加实验：思考并验证

思考一下，在使用RIPv1时，一台路由器向它的邻居路由器发送路由更新时，仅发送网络号码信息，不发送掩码。这样接受路由更新的路由器可以依据哪些条件进行处理，生成对应的掩码信息？

RIPv1和RIPv2怎样实现相互兼容？

最终设备配置

```
[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
```

```
interface Serial1/0/0
 link-protocol ppp
 description this port connect to R2-S1/0/0
 ip address 10.0.12.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
rip 1
 version 2
 network 10.0.0.0
#
return

[R2]display current-configuration
[V200R001C01SPC300]
#
 sysname R2
#
interface Serial1/0/0
 link-protocol ppp
 description this port connect to R1-S1/0/0
 ip address 10.0.12.2 255.255.255.0
#
interface Serial2/0/0
 link-protocol ppp
 description this port connect to R3-S2/0/0
 ip address 10.0.23.2 255.255.255.0
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
rip 1
 version 2
 network 10.0.0.0
 import-route static
#
 ip route-static 172.16.3.0 255.255.255.0 10.0.23.3
#
return

[R3]display current-configuration
[V200R001C01SPC300]
```

```
#
 sysname R3
#
interface Serial2/0/0
 link-protocol ppp
 description this port connects to R2-S2/0/0
 ip address 10.0.23.3 255.255.255.0
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
interface LoopBack1
 ip address 172.16.3.3 255.255.255.0
#
rip 1
 version 2
 network 10.0.0.0
#
return
```

实验 3-2 RIPv2 路由汇总和认证

学习目的

- 了解路由汇总对路由器性能提升的意义
- 理解RIPv2的路由汇总的方法
- 掌握配置RIPv2手动路由汇总的方法
- 掌握配置RIP认证的方法
- 掌握RIP认证失败时故障排除的方法

拓扑图

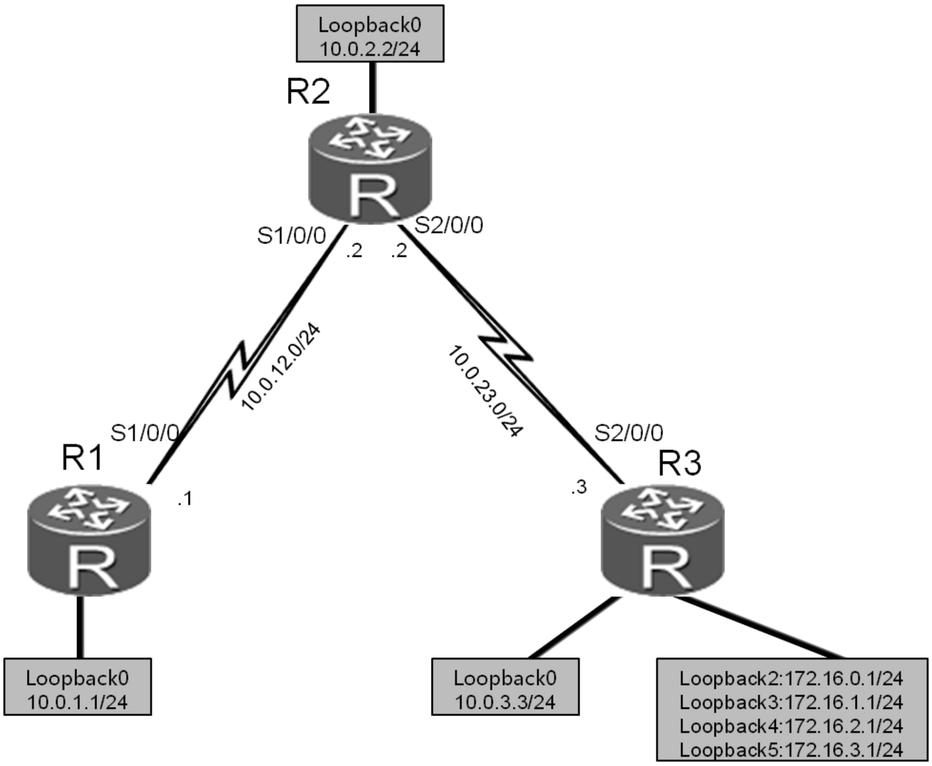


图3.2 RIPv2路由汇总及认证实验拓扑图

场景

你是公司的网络工程师，现在公司的网络规模比较小，所以你选择使用RIPv2来作为动态路由协议。但是发现路由条目很多，本着优化路由操作的原则，你选择采用RIP的手动汇总来进行路由信息的控制和传递。

此外，由于担心恶意的破坏者会伪装成合法路由器，接收并可能修改我们的路由信息，你决定使用RIPv2中的认证功能来保护网络。

学习任务

步骤一.　基础配置与 IP 编址

配置R1、R2、R3的设备名称，配置IP地址。

```
<Huawei>system
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 24
[R1-Serial1/0/0]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24


<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface serial 1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 24
[R2-Serial1/0/0]interface serial 2/0/0
[R2-Serial2/0/0]ip address 10.0.23.2 24
[R2-Serial2/0/0]interface loopback0
[R2-LoopBack0]ip address 10.0.2.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface Serial 2/0/0
[R3-Serial2/0/0]ip address 10.0.23.3 24
[R3-Serial2/0/0]interface loopback0
[R3-LoopBack0]ip address 10.0.3.3 24
```

```
[R3-LoopBack0]interface loopback 2
[R3-LoopBack2]ip address 172.16.0.1 24
[R3-LoopBack2]interface loopback 3
[R3-LoopBack3]ip address 172.16.1.1 24
[R3-LoopBack3]interface loopback 4
[R3-LoopBack4]ip address 172.16.2.1 24
[R3-LoopBack4]interface loopback 5
[R3-LoopBack5]ip address 172.16.3.1 24
```

完成配置后，测试网络连通性。

```
<R1>ping 10.0.12.2
  PING 10.0.12.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.12.2: bytes=56 Sequence=1 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=2 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=3 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=4 ttl=255 time=30 ms
    Reply from 10.0.12.2: bytes=56 Sequence=5 ttl=255 time=30 ms

  --- 10.0.12.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 30/30/30 ms

<R2>ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=255 time=31 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=255 time=31 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=255 time=41 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=255 time=31 ms
    Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=255 time=41 ms

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 31/35/41 ms
```

步骤二. 配置 RIPv2

在R1、R2、R3上配置路由协议RIP，使用版本2。

```
[R1]rip 1
[R1-rip-1]network 10.0.0.0
[R1-rip-1]version 2

[R2]rip 1
[R2-rip-1]network 10.0.0.0
[R2-rip-1]version 2

[R3]rip 1
[R3-rip-1]network 172.16.0.0
[R3-rip-1]network 10.0.0.0
[R3-rip-1]version 2
```

查看R1的路由表。

```
<R1>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 18      Routes : 18

Destination/Mask    Proto   Pre  Cost     Flags NextHop       Interface

      10.0.1.0/24  Direct  0    0    D  10.0.1.1       LoopBack0
      10.0.1.1/32  Direct  0    0    D  127.0.0.1      InLoopBack0
    10.0.1.255/32  Direct  0    0    D  127.0.0.1      InLoopBack0
      10.0.2.0/24  RIP     100  1    D  10.0.12.2      Serial1/0/0
      10.0.3.0/24  RIP     100  2    D  10.0.12.2      Serial1/0/0
     10.0.12.0/24  Direct  0    0    D  10.0.12.1      Serial1/0/0
     10.0.12.1/32  Direct  0    0    D  127.0.0.1      InLoopBack0
     10.0.12.2/32  Direct  0    0    D  10.0.12.2      Serial1/0/0
   10.0.12.255/32  Direct  0    0    D  127.0.0.1      InLoopBack0
     10.0.23.0/24  RIP     100  1    D  10.0.12.2      Serial1/0/0
     127.0.0.0/8   Direct  0    0    D  127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct  0    0    D  127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0    D  127.0.0.1      InLoopBack0
    172.16.0.0/24  RIP     100  2    D  10.0.12.2      Serial1/0/0
    172.16.1.0/24  RIP     100  2    D  10.0.12.2      Serial1/0/0
    172.16.2.0/24  RIP     100  2    D  10.0.12.2      Serial1/0/0
    172.16.3.0/24  RIP     100  2    D  10.0.12.2      Serial1/0/0
255.255.255.255/32  Direct  0    0    D  127.0.0.1      InLoopBack0
```

以上灰色突出显示部分可以看出，此时R1学习到的是没有汇总的明细路由。

测试网络连通性。

```
<R1>ping 172.16.0.1
  PING 172.16.0.1: 56  data bytes, press CTRL_C to break
    Reply from 172.16.0.1: bytes=56 Sequence=1 ttl=254 time=80 ms
    Reply from 172.16.0.1: bytes=56 Sequence=2 ttl=254 time=79 ms
    Reply from 172.16.0.1: bytes=56 Sequence=3 ttl=254 time=79 ms
    Reply from 172.16.0.1: bytes=56 Sequence=4 ttl=254 time=79 ms
    Reply from 172.16.0.1: bytes=56 Sequence=5 ttl=254 time=79 ms

  --- 172.16.0.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 79/79/80 ms
```

步骤三.　在 R2 上配置 RIP 手动路由汇总

在R2接口S1/0/0下使用**rip summary-address**命令配置RIP手动汇总路由，将172.16.0.0/24、172.16.1.0/24、172.16.2.0/24、172.16.3.0/24四条路由汇总成一条172.16.0.0/16的路由。

```
[R2]interface serial1/0/0
[R2-Serial1/0/0]rip summary-address 172.16.0.0 255.255.0.0
```

查看路由信息，注意汇总信息的情况。

```
<R1>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 15       Routes : 15

Destination/Mask   Proto  Pre  Cost  Flags NextHop         Interface

      10.0.1.0/24  Direct  0    0     D   10.0.1.1        LoopBack0
      10.0.1.1/32  Direct  0    0     D   127.0.0.1       InLoopBack0
    10.0.1.255/32  Direct  0    0     D   127.0.0.1       InLoopBack0
      10.0.2.0/24  RIP     100  1     D   10.0.12.2       Serial1/0/0
      10.0.3.0/24  RIP     100  2     D   10.0.12.2       Serial1/0/0
     10.0.12.0/24  Direct  0    0     D   10.0.12.1       Serial1/0/0
     10.0.12.1/32  Direct  0    0     D   127.0.0.1       InLoopBack0
     10.0.12.2/32  Direct  0    0     D   10.0.12.2       Serial1/0/0
```

```
   10.0.12.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.23.0/24  RIP     100  1    D   10.0.12.2       Serial1/0/0
      127.0.0.0/8  Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    172.16.0.0/16  RIP     100  2    D   10.0.12.2       Serial1/0/0
255.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
```

以上灰色突出显示部分可以看出，此时路由表里面只显示了汇总路由，不再显示明细路由了。

测试网络连通是否依然正常。

```
<R1>ping 172.16.0.1
  PING 172.16.0.1: 56  data bytes, press CTRL_C to break
    Reply from 172.16.0.1: bytes=56 Sequence=1 ttl=254 time=60 ms
    Reply from 172.16.0.1: bytes=56 Sequence=2 ttl=254 time=59 ms
    Reply from 172.16.0.1: bytes=56 Sequence=3 ttl=254 time=80 ms
    Reply from 172.16.0.1: bytes=56 Sequence=4 ttl=254 time=60 ms
    Reply from 172.16.0.1: bytes=56 Sequence=5 ttl=254 time=60 ms

  --- 172.16.0.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 59/63/80 ms
```

如上显示路由汇总操作并未影响网络连通性。

步骤四. 配置路由认证

在实验中，配置R1与R2之间使用明文认证，R2与R3之间使用MD5认证。认证密码均为“huawei”。

```
[R1]interface serial 1/0/0
[R1-Serial1/0/0]rip authentication-mode simple huawei

[R2]interface serial 1/0/0
[R2-Serial1/0/0]rip authentication-mode simple huawei
[R2-Serial1/0/0]quit
[R2]interface serial 2/0/0
[R2-Serial2/0/0]rip authentication-mode md5 usual huawei

[R3]interface serial 2/0/0
```

```
[R3-Serial2/0/0]rip authentication-mode md5 usual huawei
```

配置完成后，测试网络是否正常。

```
<R1>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 15      Routes : 15

Destination/Mask   Proto  Pre  Cost Flags NextHop      Interface

      10.0.1.0/24  Direct  0    0    D   10.0.1.1       LoopBack0
      10.0.1.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
    10.0.1.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
      10.0.2.0/24  RIP     100  1    D   10.0.12.2      Serial1/0/0
      10.0.3.0/24  RIP     100  2    D   10.0.12.2      Serial1/0/0
     10.0.12.0/24  Direct  0    0    D   10.0.12.1      Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.12.2/32  Direct  0    0    D   10.0.12.2      Serial1/0/0
   10.0.12.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.23.0/24  RIP     100  1    D   10.0.12.2      Serial1/0/0
     127.0.0.0/8   Direct  0    0    D   127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
    172.16.0.0/16  RIP     100  2    D   10.0.12.2      Serial1/0/0
255.255.255.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0

<R2>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 21      Routes : 21

Destination/Mask   Proto  Pre  Cost Flags NextHop      Interface

      10.0.1.0/24  RIP     100  1    D   10.0.12.1      Serial1/0/0
      10.0.2.0/24  Direct  0    0    D   10.0.2.2       LoopBack0
      10.0.2.2/32  Direct  0    0    D   127.0.0.1      InLoopBack0
    10.0.2.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
      10.0.3.0/24  RIP     100  1    D   10.0.23.3      Serial2/0/0
     10.0.12.0/24  Direct  0    0    D   10.0.12.2      Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   10.0.12.1      Serial1/0/0
     10.0.12.2/32  Direct  0    0    D   127.0.0.1      InLoopBack0
```

```
   10.0.12.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.23.0/24  Direct  0    0    D   10.0.23.2       Serial2/0/0
     10.0.23.2/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.23.3/32  Direct  0    0    D   10.0.23.3       Serial2/0/0
   10.0.23.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
      127.0.0.0/8  Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    172.16.0.0/24  RIP     100  1    D   10.0.23.3       Serial2/0/0
    172.16.1.0/24  RIP     100  1    D   10.0.23.3       Serial2/0/0
    172.16.2.0/24  RIP     100  1    D   10.0.23.3       Serial2/0/0
    172.16.3.0/24  RIP     100  1    D   10.0.23.3       Serial2/0/0
255.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0

<R3>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 26       Routes : 26

Destination/Mask  Proto   Pre  Cost Flags NextHop      Interface

      10.0.1.0/24  RIP     100  2    D   10.0.23.2       Serial2/0/0
      10.0.2.0/24  RIP     100  1    D   10.0.23.2       Serial2/0/0
      10.0.3.0/24  Direct  0    0    D   10.0.3.3        LoopBack0
      10.0.3.3/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    10.0.3.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.12.0/24  RIP     100  1    D   10.0.23.2       Serial2/0/0
     10.0.23.0/24  Direct  0    0    D   10.0.23.3       Serial2/0/0
     10.0.23.2/32  Direct  0    0    D   10.0.23.2       Serial2/0/0
     10.0.23.3/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   10.0.23.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
      127.0.0.0/8  Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    172.16.0.0/24  Direct  0    0    D   172.16.0.1      LoopBack2
    172.16.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
  172.16.0.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    172.16.1.0/24  Direct  0    0    D   172.16.1.1      LoopBack3
    172.16.1.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
  172.16.1.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    172.16.2.0/24  Direct  0    0    D   172.16.2.1      LoopBack4
    172.16.2.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
```

```
  172.16.2.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    172.16.3.0/24  Direct  0    0    D   172.16.3.1      LoopBack5
    172.16.3.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
  172.16.3.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0   D   127.0.0.1       InLoopBack0
```

步骤五. RIPv2 故障排除

修改R2接口S1/0/0的RIP认证密码为"huawei2"。

```
[R2]interface serial1/0/0
[R2-Serial1/0/0]rip authentication-mode simple huawei2
```

使用如下命令清除R1在密码更改之前从R2学到的路由信息。

```
<R1>reset ip routing-table statistics protocol rip
```

然后查看R1的路由表，确认路由信息的学习情况。

```
<R1>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 11      Routes : 11

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.1.0/24  Direct  0    0           D   10.0.1.1        LoopBack0
      10.0.1.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.1.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.12.0/24  Direct  0    0           D   10.0.12.1       Serial1/0/0
     10.0.12.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.12.2/32  Direct  0    0           D   10.0.12.2       Serial1/0/0
   10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0          D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0          D   127.0.0.1       InLoopBack0
```

由于R1与R2之间的RIP认证密码不匹配，所以R1收不到从R2发来的任何RIP路由。

恢复R2接口S1/0/0的RIP认证密码为"huawei"，与R1匹配。

```
[R2]interface serial1/0/0
[R2-Serial1/0/0]rip authentication-mode simple huawei
```

更改R2接口S2/0/0的认证模式为明文认证。

```
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]rip authentication-mode simple huawei
```

使用如下命令清除R3在密码错误之前从R2学到的路由信息。

```
<R3>reset ip routing-table statistics protocol rip
```

然后查看R3的路由表。

```
<R3>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 23      Routes : 23

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

      10.0.3.0/24  Direct  0    0          D   10.0.3.3       LoopBack0
      10.0.3.3/32  Direct  0    0          D   127.0.0.1      InLoopBack0
    10.0.3.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
     10.0.23.0/24  Direct  0    0          D   10.0.23.3      Serial2/0/0
     10.0.23.2/32  Direct  0    0          D   10.0.23.2      Serial2/0/0
     10.0.23.3/32  Direct  0    0          D   127.0.0.1      InLoopBack0
   10.0.23.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
     127.0.0.0/8   Direct  0    0          D   127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
    172.16.0.0/24  Direct  0    0          D   172.16.0.1     LoopBack2
    172.16.0.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
  172.16.0.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
    172.16.1.0/24  Direct  0    0          D   172.16.1.1     LoopBack3
    172.16.1.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
  172.16.1.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
    172.16.2.0/24  Direct  0    0          D   172.16.2.1     LoopBack4
    172.16.2.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
  172.16.2.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
    172.16.3.0/24  Direct  0    0          D   172.16.3.1     LoopBack5
    172.16.3.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
  172.16.3.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
```

```
255.255.255.255/32  Direct  0    0         D   127.0.0.1      InLoopBack0
```

由于R2与R3之间RIP认证模式不匹配，所以R3收不到从R2发来的任何路由。

恢复R2接口S2/0/0的RIP认证模式为MD5，与R3匹配。

```
[R2]interface serial2/0/0
[R2-Serial2/0/0]rip authentication-mode md5 usual huawei
```

确认R1、R2和R3的路由表中路由条目正常。

```
<R1>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 15      Routes : 15

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

      10.0.1.0/24  Direct  0    0    D   10.0.1.1       LoopBack0
      10.0.1.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
    10.0.1.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
      10.0.2.0/24  RIP     100  1    D   10.0.12.2      Serial1/0/0
      10.0.3.0/24  RIP     100  2    D   10.0.12.2      Serial1/0/0
     10.0.12.0/24  Direct  0    0    D   10.0.12.1      Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.12.2/32  Direct  0    0    D   10.0.12.2      Serial1/0/0
   10.0.12.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.23.0/24  RIP     100  1    D   10.0.12.2      Serial1/0/0
     127.0.0.0/8   Direct  0    0    D   127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
    172.16.0.0/16  RIP     100  2    D   10.0.12.2      Serial1/0/0
255.255.255.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0

<R2>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 21      Routes : 21

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

      10.0.1.0/24  RIP     100  1    D   10.0.12.1      Serial1/0/0
      10.0.2.0/24  Direct  0    0    D   10.0.2.2       LoopBack0
```

```
      10.0.2.2/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.2.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
      10.0.3.0/24  RIP     100  1    D   10.0.23.3       Serial2/0/0
     10.0.12.0/24  Direct  0    0    D   10.0.12.2       Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   10.0.12.1       Serial1/0/0
     10.0.12.2/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   10.0.12.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.23.0/24  Direct  0    0    D   10.0.23.2       Serial2/0/0
     10.0.23.2/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.23.3/32  Direct  0    0    D   10.0.23.3       Serial2/0/0
   10.0.23.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    172.16.0.0/24  RIP     100  1    D   10.0.23.3       Serial2/0/0
    172.16.1.0/24  RIP     100  1    D   10.0.23.3       Serial2/0/0
    172.16.2.0/24  RIP     100  1    D   10.0.23.3       Serial2/0/0
    172.16.3.0/24  RIP     100  1    D   10.0.23.3       Serial2/0/0
255.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0


<R3>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 26       Routes : 26

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.1.0/24  RIP     100  2    D   10.0.23.2       Serial2/0/0
      10.0.2.0/24  RIP     100  1    D   10.0.23.2       Serial2/0/0
      10.0.3.0/24  Direct  0    0    D   10.0.3.3        LoopBack0
      10.0.3.3/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.3.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.12.0/24  RIP     100  1    D   10.0.23.2       Serial2/0/0
     10.0.23.0/24  Direct  0    0    D   10.0.23.3       Serial2/0/0
     10.0.23.2/32  Direct  0    0    D   10.0.23.2       Serial2/0/0
     10.0.23.3/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   10.0.23.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    172.16.0.0/24  Direct  0    0    D   172.16.0.1      LoopBack2
```

```
     172.16.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   172.16.0.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     172.16.1.0/24  Direct  0    0    D   172.16.1.1      LoopBack3
     172.16.1.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   172.16.1.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     172.16.2.0/24  Direct  0    0    D   172.16.2.1      LoopBack4
     172.16.2.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   172.16.2.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     172.16.3.0/24  Direct  0    0    D   172.16.3.1      LoopBack5
     172.16.3.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   172.16.3.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
```

附加实验：思考并验证

我们可以使用**debug**命令进行故障排除。在“步骤五”中，密码或认证类型不匹配，都可以通过**debug**命令的输出得以显示。请使用这种方式进行故障排除。

附录 A：华为路由器 RIP 协议的相关 debug 命令

```
<Huawei>debugging rip 1 ?
  brief                        Brief information about RIP events
  error                        Information about RIP Errors
  event                        Information about RIP events
  packet                       All RIP packets
  receive                      Received RIP packet information
  route-processing             Information about RIP Route-Processing
  send                         Sent RIP packet information
  timer                        Information about RIP timers
  <cr>                         Please press ENTER to execute command
```

如上仅显示部分**debug**命令。可参考使用。

最终设备配置

```
<R1>display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.1 255.255.255.0
 rip authentication-mode simple huawei
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
rip 1
 version 2
 network 10.0.0.0
#
return
```

```
<R2>display current-configuration
[V200R001C01SPC300]
#
 sysname R2
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.2 255.255.255.0
 rip authentication-mode simple huawei
 rip summary-address 172.16.0.0 255.255.0.0
#
interface Serial2/0/0
 link-protocol ppp
 ip address 10.0.23.2 255.255.255.0
 rip authentication-mode md5 usual gg^dP=F.[>=H)H2[EInB~.2#
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
rip 1
 version 2
```

```
 network 10.0.0.0
#
return


<R3>display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
interface Serial2/0/0
 link-protocol ppp
 ip address 10.0.23.3 255.255.255.0
 rip authentication-mode md5 usual gg^dP=F.[>=H)H2[EInB~.2#
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
interface LoopBack2
 ip address 172.16.0.1 255.255.255.0
#
interface LoopBack3
 ip address 172.16.1.1 255.255.255.0
#
interface LoopBack4
 ip address 172.16.2.1 255.255.255.0
#
interface LoopBack5
 ip address 172.16.3.1 255.255.255.0
#
rip 1
 version 2
 network 10.0.0.0
 network 172.16.0.0
#
return
```

第四章 OSPF的配置

实验 4-1 OSPF 单区域配置

学习目的

- 理解OSPF路由器Router ID的意义
- 掌握在特定接口或网络启用OSPF的方法
- 掌握使用**display**命令查看OSPF工作情况的方法
- 掌握使用OSPF发布默认路由的方法
- 掌握修改OSPF **hello**和**dead**时间的方法
- 掌握修改OSPF优先级的方法
- 理解OSPF在以太网上的DR/BDR选择过程

拓扑图

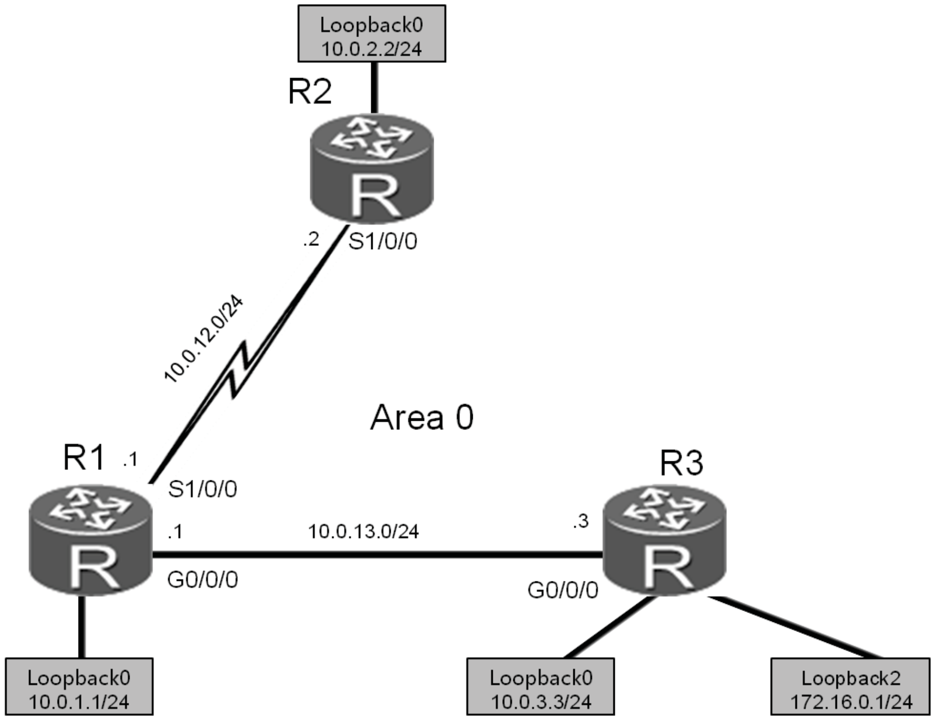


图4.1 OSPF单区域配置实验拓扑图

场景

你是公司的网络管理员。现在公司的网络准备使用OSPF协议来进行路由信息的传递。规划网络中所有路由器属于OSPF的区域0。实际使用中需要向OSPF发布默认路由，此外你也希望通过这次部署了解DR/BDR选举的机制。

学习任务

步骤一. 基本配置

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface serial1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 24
[R1-Serial1/0/0]interface GigabitEthernet 0/0/0
```

```
[R1-GigabitEthernet0/0/0]ip address 10.0.13.1 24
[R1-GigabitEthernet0/0/0]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface serial 1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 24
[R2-Serial1/0/0]interface loopback 0
[R2-LoopBack0]ip address 10.0.2.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/0
[R3-GigabitEthernet0/0/0]ip address 10.0.13.3 24
[R3-GigabitEthernet0/0/0]interface loopback 0
[R3-LoopBack0]ip address 10.0.3.3 24
[R3-LoopBack0]interface loopback 2
[R3-LoopBack2]ip address 172.16.0.1 24
```

步骤二.　OSPF 配置

定义R1的Loopback0接口地址10.0.1.1作为R1的Router ID，使用默认的OSPF进程号1，将10.0.12.0/24、10.0.13.0/24和10.0.1.0/24三个网段定义到OSPF区域0。

```
[R1]ospf 1 router-id 10.0.1.1
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0]network 10.0.1.0 0.0.0.255
[R1-ospf-1-area-0.0.0.0]network 10.0.13.0 0.0.0.255
[R1-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255
```

注意：同一个路由器可以开启多个OSPF进程，默认进程号为1，由于进程号只具有本地意义，所以同一路由域的不同路由器可以使用相同或不同的OSPF进程号；**network**命令后面需使用反掩码。

定义R2的Loopback0接口地址10.0.2.2作为R2的Router ID，配置使用OSPF进程号10，将10.0.12.0/24和10.0.2.0/24两个网段定义到OSPF区域0。

```
[R2]ospf 10 router-id 10.0.2.2
[R2-ospf-10]area 0
```

```
[R2-ospf-10-area-0.0.0.0]network 10.0.12.0 0.0.0.255
[R2-ospf-10-area-0.0.0.0]network 10.0.2.0 0.0.0.255
```

定义R3的Loopback0接口地址10.0.3.3作为R3的Router ID，配置使用OSPF进程号100，将10.0.13.0/24和10.0.3.0/24两个网段定义到OSPF区域0。

```
[R3]ospf 100 router-id 10.0.3.3
[R3-ospf-100]area 0
[R3-ospf-100-area-0.0.0.0]network 10.0.13.0 0.0.0.255
[R3-ospf-100-area-0.0.0.0]network 10.0.3.0 0.0.0.255
```

步骤三. OSPF 验证

查看R1、R2和R3的路由表。

```
<R1>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 16      Routes : 16

Destination/Mask    Proto   Pre  Cost     Flags NextHop       Interface

      10.0.1.0/24  Direct  0    0    D   10.0.1.1       LoopBack0
      10.0.1.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
    10.0.1.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
      10.0.2.2/32  OSPF    10   1562 D   10.0.12.2      Serial1/0/0
      10.0.3.3/32  OSPF    10   1    D   10.0.13.3      GigabitEthernet0/0/0
     10.0.12.0/24  Direct  0    0    D   10.0.12.1      Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.12.2/32  Direct  0    0    D   10.0.12.2      Serial1/0/0
   10.0.12.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.13.0/24  Direct  0    0    D   10.0.13.1      GigabitEthernet0/0/0
     10.0.13.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
   10.0.13.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     127.0.0.0/8   Direct  0    0    D   127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
255.255.255.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0

<R2>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
```

```
Routing Tables: Public
        Destinations : 14       Routes : 14

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.1.1/32  OSPF    10   1562        D   10.0.12.1       Serial1/0/0
      10.0.2.0/24  Direct  0    0           D   10.0.2.2        LoopBack0
      10.0.2.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.2.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.3.3/32  OSPF    10   1563        D   10.0.12.1       Serial1/0/0
     10.0.12.0/24  Direct  0    0           D   10.0.12.2       Serial1/0/0
     10.0.12.1/32  Direct  0    0           D   10.0.12.1       Serial1/0/0
     10.0.12.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
   10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.13.0/24  OSPF    10   1563        D   10.0.12.1       Serial1/0/0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0

<R3>display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 16       Routes : 16

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface
      10.0.1.1/32  OSPF    10   1    D   10.0.13.1       GigabitEthernet0/0/0
      10.0.2.2/32  OSPF    10   1563 D   10.0.13.1       GigabitEthernet0/0/0
      10.0.3.0/24  Direct  0    0    D   10.0.3.3        LoopBack0
      10.0.3.3/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    10.0.3.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     10.0.12.0/24  OSPF    10   1563 D   10.0.13.1       GigabitEthernet0/0/0
     10.0.13.0/24  Direct  0    0    D   10.0.13.3       GigabitEthernet0/0/0
     10.0.13.3/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   10.0.13.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    172.16.0.0/24  Direct  0    0    D   172.16.0.1      LoopBack2
    172.16.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
  172.16.0.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
```

测试R2到10.0.1.1和10.0.3.3的连通性。

```
[R2]ping 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=255 time=37 ms
    Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=255 time=42 ms
    Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=255 time=42 ms
    Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=255 time=45 ms
    Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=255 time=42 ms

  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 37/41/45 ms

[R2]ping 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=254 time=37 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=254 time=42 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=254 time=42 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=254 time=42 ms
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=254 time=42 ms

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 37/41/42 ms
```

使用**display ip routing-table protocol ospf**命令可以查看通过OSPF学到的路由，同样可以在R2和R3上进行相同操作。

```
[R1]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
        Destinations : 2       Routes : 2

OSPF routing table status : <Active>
        Destinations : 2       Routes : 2

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface
```

```
      10.0.2.2/32  OSPF    10   1562 D   10.0.12.2      Serial1/0/0
      10.0.3.3/32  OSPF    10   1    D   10.0.13.3      GigabitEthernet0/0/0

OSPF routing table status : <Inactive>
       Destinations : 0      Routes : 0
```

使用**display ospf peer**命令查看OSPF邻居状态。

```
[R1]display ospf peer

       OSPF Process 1 with Router ID 10.0.1.1
             Neighbors

 Area 0.0.0.0 interface 10.0.12.1(Serial1/0/0)'s neighbors
 Router ID: 10.0.2.2        Address: 10.0.12.2
   State: Full  Mode:Nbr is  Master  Priority: 1
   DR: None   BDR: None   MTU: 0
   Dead timer due in 30  sec
   Retrans timer interval: 5
   Neighbor is up for 00:09:19
   Authentication Sequence: [ 0 ]

             Neighbors

 Area 0.0.0.0 interface 10.0.13.1(GigabitEthernet0/0/0)'s neighbors
 Router ID: 10.0.3.3        Address: 10.0.13.3
   State: Full  Mode:Nbr is  Master  Priority: 1
   DR: 10.0.13.1  BDR: 10.0.13.3  MTU: 0
   Dead timer due in 37  sec
   Retrans timer interval: 5
   Neighbor is up for 00:10:04
   Authentication Sequence: [ 0 ]
```

使用**display ospf peer**命令可以显示邻居的详细信息，由上输出可以看出，R1有两个邻居R2（Router ID: 10.0.2.2）和R3（Router ID: 10.0.3.3），而且邻居状态都是完全邻接状态。另外也可以使用**display ospf peer brief**命令以更简洁的方式查看邻居状态。

```
[R1]display ospf peer brief

       OSPF Process 1 with Router ID 10.0.1.1
              Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id         Interface                     Neighbor id     State
```

```
 0.0.0.0        Serial1/0/0                  10.0.2.2       Full
 0.0.0.0        GigabitEthernet0/0/0          10.0.3.3       Full
 ----------------------------------------------------------------------------

[R2]display ospf peer brief

       OSPF Process 10 with Router ID 10.0.2.2
              Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id        Interface                    Neighbor id     State
 0.0.0.0        Serial1/0/0                  10.0.1.1       Full
 ----------------------------------------------------------------------------

[R3]display ospf peer brief

       OSPF Process 100 with Router ID 10.0.3.3
              Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id        Interface                    Neighbor id     State
 0.0.0.0        GigabitEthernet0/0/0          10.0.1.1       Full
 ----------------------------------------------------------------------------
```

步骤四. OSPF Hello 和 Dead 时间参数修改

使用**display**命令查看R1接口G0/0/0运行的OSPF默认的Hello和Dead时间参数。

```
[R1]display ospf interface GigabitEthernet 0/0/0

       OSPF Process 1 with Router ID 10.0.1.1
             Interfaces


 Interface: 10.0.13.1 (GigabitEthernet0/0/0)
 Cost: 1      State: DR      Type: Broadcast    MTU: 1500
 Priority: 1
 Designated Router: 10.0.13.1
 Backup Designated Router: 10.0.13.3
 Timers: Hello 10 , Dead 40 , Poll  120 , Retransmit 5 , Transmit Delay 1
```

使用**ospf timer**命令修改R1接口G0/0/0接口Hello和Dead时间参数，分别配置为15s和60s。

```
[R1]interface GigabitEthernet 0/0/0
[R1-GigabitEthernet0/0/0]ospf timer hello 15
[R1-GigabitEthernet0/0/0]ospf timer dead 60
[R1-GigabitEthernet0/0/0]display ospf interface GigabitEthernet 0/0/0

       OSPF Process 1 with Router ID 10.0.1.1
              Interfaces


 Interface: 10.0.13.1 (GigabitEthernet0/0/0)
 Cost: 1      State: DR       Type: Broadcast    MTU: 1500
 Priority: 1
 Designated Router: 10.0.13.1
 Backup Designated Router: 10.0.13.3
 Timers: Hello 15 , Dead 60 , Poll  120 , Retransmit 5 , Transmit Delay 1
```

在R1上查看OSPF邻居状态。

```
[R1-Ethernet3/0/0]display ospf peer brief

       OSPF Process 1 with Router ID 10.0.1.1
               Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id         Interface                     Neighbor id      State
 0.0.0.0         Serial1/0/0                    10.0.2.2        Full
 ----------------------------------------------------------------------------
```

由以上输出可以看出，此时R1只有一个邻居R2。因为R1与R3之间的Hello和Dead时间参数不匹配，无法建立邻居关系。

使用**ospf timer**命令修改R3接口G0/0/0接口Hello和Dead时间参数分别为为15s和60s。

```
[R3]interface GigabitEthernet 0/0/0
[R3-GigabitEthernet0/0/0]ospf timer hello 15
[R3-GigabitEthernet0/0/0]ospf timer dead 60
[R3-GigabitEthernet0/0/0]display ospf interface GigabitEthernet 0/0/0

      OSPF Process 100 with Router ID 10.0.3.3
              Interfaces


 Interface: 10.0.13.3 (GigabitEthernet0/0/0)
 Cost: 1      State: DR       Type: Broadcast    MTU: 1500
 Priority: 1
```

```
 Designated Router: 10.0.13.3
 Backup Designated Router: 10.0.13.1
 Timers: Hello 15 , Dead 60 , Poll  120 , Retransmit 5 , Transmit Delay 1
```

再次在R1上查看OSPF邻居状态。

```
[R1]display ospf peer brief
       OSPF Process 1 with Router ID 10.0.1.1
              Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id         Interface                     Neighbor id      State
 0.0.0.0         Serial1/0/0                    10.0.2.2        Full
 0.0.0.0         GigabitEthernet0/0/0            10.0.3.3        Full
 ----------------------------------------------------------------------------
```

步骤五. OSPF 缺省路由发布及验证

在R3上配置默认路由并发布到OSPF域内。

```
[R3]ip route-static 0.0.0.0 0 LoopBack 2
[R3]ospf 100
[R3-ospf-100]default-route-advertise
```

查看R1和R2的路由表，可以看到R1和R2都学到了R3发布的默认路由。

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
----------------------------------------------------------------------------
Routing Tables: Public
       Destinations : 17      Routes : 17

Destination/Mask    Proto   Pre  Cost     Flags NextHop       Interface

       0.0.0.0/0   O_ASE   150  1     D  10.0.13.3      GigabitEthernet0/0/0
      10.0.1.0/24  Direct  0    0     D  10.0.1.1       LoopBack0
      10.0.1.1/32  Direct  0    0     D  127.0.0.1      InLoopBack0
    10.0.1.255/32  Direct  0    0     D  127.0.0.1      InLoopBack0
      10.0.2.2/32  OSPF    10   1562  D  10.0.12.2      Serial1/0/0
      10.0.3.3/32  OSPF    10   1     D  10.0.13.3      GigabitEthernet0/0/0
     10.0.12.0/24  Direct  0    0     D  10.0.12.1      Serial1/0/0
     10.0.12.1/32  Direct  0    0     D  127.0.0.1      InLoopBack0
     10.0.12.2/32  Direct  0    0     D  10.0.12.2      Serial1/0/0
   10.0.12.255/32  Direct  0    0     D  127.0.0.1      InLoopBack0
```

```
     10.0.13.0/24  Direct  0    0    D   10.0.13.1       GigabitEthernet0/0/0
     10.0.13.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
   10.0.13.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0

[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 15      Routes : 15

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

       0.0.0.0/0   O_ASE   150  1           D   10.0.12.1       Serial1/0/0
      10.0.1.1/32  OSPF    10   1562        D   10.0.12.1       Serial1/0/0
      10.0.2.0/24  Direct  0    0           D   10.0.2.2        LoopBack0
      10.0.2.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.2.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.3.3/32  OSPF    10   1563        D   10.0.12.1       Serial1/0/0
     10.0.12.0/24  Direct  0    0           D   10.0.12.2       Serial1/0/0
     10.0.12.1/32  Direct  0    0           D   10.0.12.1       Serial1/0/0
     10.0.12.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
   10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.13.0/24  OSPF    10   1563        D   10.0.12.1       Serial1/0/0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

使用**ping**命令测试从R2到172.16.0.1的连通性。

```
<R2>ping 172.16.0.1
  PING 172.16.0.1: 56  data bytes, press CTRL_C to break
    Reply from 172.16.0.1: bytes=56 Sequence=1 ttl=254 time=47 ms
    Reply from 172.16.0.1: bytes=56 Sequence=2 ttl=254 time=37 ms
    Reply from 172.16.0.1: bytes=56 Sequence=3 ttl=254 time=37 ms
    Reply from 172.16.0.1: bytes=56 Sequence=4 ttl=254 time=37 ms
    Reply from 172.16.0.1: bytes=56 Sequence=5 ttl=254 time=37 ms

  --- 172.16.0.1 ping statistics ---
    5 packet(s) transmitted
```

```
5 packet(s) received
0.00% packet loss
round-trip min/avg/max = 37/39/47 ms
```

步骤六. OSPF DR/BDR 选举控制

使用**display ospf peer**命令查看当前R1和R3的DR/BDR角色信息。

```
[R1]display ospf peer 10.0.3.3

       OSPF Process 1 with Router ID 10.0.1.1
              Neighbors

 Area 0.0.0.0 interface 10.0.13.1(GigabitEthernet0/0/0)'s neighbors
 Router ID: 10.0.3.3       Address: 10.0.13.3
   State: Full  Mode:Nbr is  Master  Priority: 1
   DR: 10.0.13.3  BDR: 10.0.13.1  MTU: 0
   Dead timer due in 49  sec
   Retrans timer interval: 5
   Neighbor is up for 00:17:40
   Authentication Sequence: [ 0 ]
```

以上输出表明，由于默认路由器优先级（数值为1）相同，但R3的Router ID 10.0.3.3大于R1的Router ID 10.0.1.1，所以R3为DR，R1为BDR。

使用**ospf dr-priority**命令修改R1和R3的DR路由优先级。

```
[R1]interface GigabitEthernet 0/0/0
[R1-GigabitEthernet0/0/0]ospf dr-priority 200

[R3]interface GigabitEthernet 0/0/0
[R3-GigabitEthernet0/0/0]ospf dr-priority 100
```

由于DR/BDR选举默认为不抢占模式，因此在修改了路由器优先级后不会自动重新选举DR，需要重置R1和R3的邻居关系。

关闭并重新开启R1和R3上的接口GigabitEthernet 0/0/0，使R1与R3邻居关系重置。

```
[R1]interface GigabitEthernet0/0/0
[R1-GigabitEthernet0/0/0]shutdown

[R3]interface GigabitEthernet0/0/0
[R3-GigabitEthernet0/0/0]shutdown
```

```
[R1-GigabitEthernet0/0/0]undo shutdown

[R3-GigabitEthernet0/0/0]undo shutdown
```

使用**display ospf peer**命令查看当前R1和R3的DR/BDR角色信息。

```
[R1-GigabitEthernet 0/0/0]display ospf peer 10.0.3.3

        OSPF Process 1 with Router ID 10.0.1.1
               Neighbors

 Area 0.0.0.0 interface 10.0.13.1(GigabitEthernet0/0/0)'s neighbors
 Router ID: 10.0.3.3        Address: 10.0.13.3
   State: Full  Mode:Nbr is  Master  Priority: 100
   DR: 10.0.13.1  BDR: 10.0.13.3  MTU: 0
   Dead timer due in 52  sec
   Retrans timer interval: 5
   Neighbor is up for 00:00:25
   Authentication Sequence: [ 0 ]
```

以上输出可以看出，此时由于R1的路由器优先级比R3高，所以R1成为了DR，R3成为了BDR。

附加实验：思考并验证

思考修改Hello时间和Dead时间,修改的目的是什么？

同一个区域内部，所有路由器的Hello间隔时间和Dead间隔时间必须一样吗？同一台路由器不同的接口Hello间隔时间和Dead间隔时间必须一样吗？为什么？

OSPF在哪些网络会选择DR/BDR？

三个路由器均配置有环回接口，掩码定义为24位。为什么环回口连接的网络被其他路由器学习到之后，会显示对应的路由掩码为32位？

最终设备配置

```
[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
```

```
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.1 255.255.255.0
#
interface GigabitEthernet0/0/0
 ip address 10.0.13.1 255.255.255.0
 ospf dr-priority 200
 ospf timer hello 15
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
ospf 1 router-id 10.0.1.1
 area 0.0.0.0
  network 10.0.1.0 0.0.0.255
  network 10.0.13.0 0.0.0.255
  network 10.0.12.0 0.0.0.255
#
return

[R2]display current-configuration
[V200R001C01SPC300]
#
 sysname R2
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.2 255.255.255.0
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
ospf 10 router-id 10.0.2.2
 area 0.0.0.0
  network 10.0.2.0 0.0.0.255
  network 10.0.12.0 0.0.0.255
#
return

[R3]display current-configuration
[V200R001C01SPC300]
#
 sysname R3
```

```
#
interface GigabitEthernet0/0/0
 ip address 10.0.13.3 255.255.255.0
 ospf dr-priority 100
 ospf timer hello 15
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
interface LoopBack2
 ip address 172.16.0.1 255.255.255.0
#
ospf 100 router-id 10.0.3.3
 default-route-advertise
 area 0.0.0.0
  network 10.0.13.0 0.0.0.255
  network 10.0.3.0 0.0.0.255
#
 ip route-static 0.0.0.0 0.0.0.0 LoopBack2
#
return
```

实验 4-2 OSPF 多区域、认证配置

学习目的

- 了解OSPF多区域设计的优点
- 理解OSPF多区域路由信息的交换方式
- 掌握OSPF多区域配置命令
- 掌握OSPF的认证配置方法
- 掌握OSPF邻居无法建立的故障排除方法

拓扑图

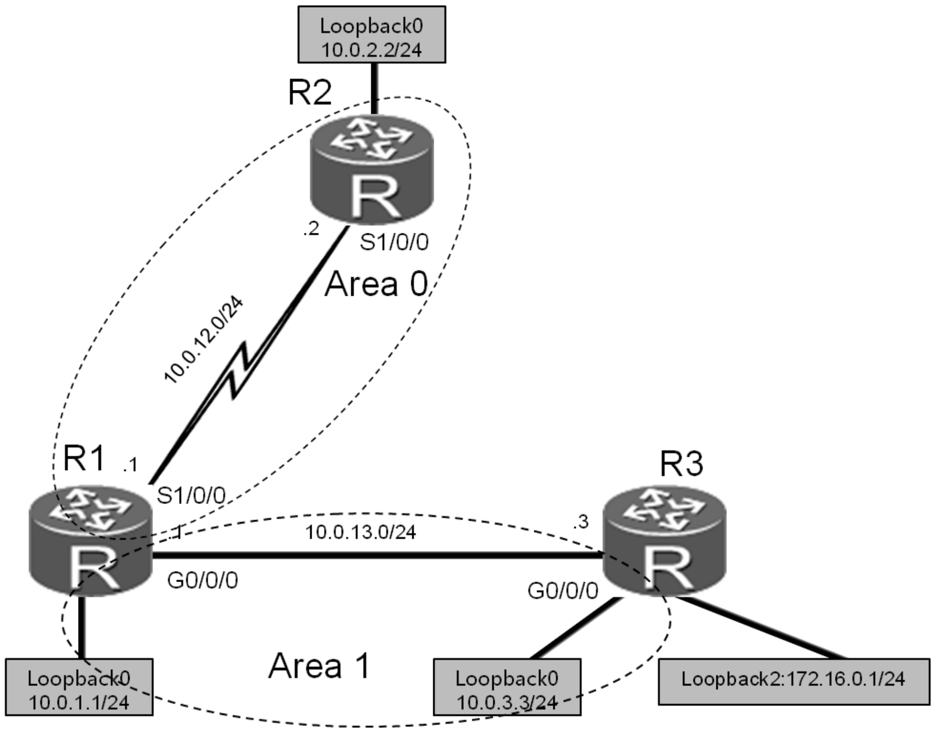


图4.2 OSPF多区域及认证实验拓扑图

场景

你是你们公司的网络管理员。现在公司的网络准备使用OSPF协议来进行路由信息的传递。为应对网络规模日益增大的问题，你决定使用OSPF的多区域模式来规划网络。此外为保证信息安全，你采用了OSPF的认证。在配置过程中，你也了解了OSPF中各种类型LSA的作用。

学习任务

步骤一. 基本配置

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface serial1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 24
[R1-Serial1/0/0]interface GigabitEthernet 0/0/0
[R1-GigabitEthernet0/0/0]ip address 10.0.13.1 24
[R1-GigabitEthernet0/0/0]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface serial 1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 24
[R2-Serial1/0/0]interface loopback 0
[R2-LoopBack0]ip address 10.0.2.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/0
[R3-GigabitEthernet0/0/0]ip address 10.0.13.3 24
[R3-GigabitEthernet0/0/0]interface loopback 0
[R3-LoopBack0]ip address 10.0.3.3 24
[R3-LoopBack0]interface loopback 2
[R3-LoopBack2]ip address 172.16.0.1 24
```

步骤二. OSPF 多区域配置

R1为ABR，10.0.12.0/24网段属于区域0，10.0.13.0/24与10.0.1.0/24网段属于区域1。

```
[R1]ospf 1 router-id 10.0.1.1
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255
[R1-ospf-1-area-0.0.0.0]quit
[R1-ospf-1]area 1
[R1-ospf-1-area-0.0.0.1]network 10.0.13.0 0.0.0.255
[R1-ospf-1-area-0.0.0.1]network 10.0.1.0 0.0.0.255
```

R2为骨干区域普通内部路由器，属于区域0。

```
[R2]ospf 1 router-id 10.0.2.2
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255
[R2-ospf-1-area-0.0.0.0]network 10.0.2.0 0.0.0.255
```

R3为ASBR，10.0.13.0/24和10.0.3.0/24两个网段属于区域1，172.16.0.0/24网段不属于OSPF路由域，不用通告进OSPF进程。

```
[R3]ospf 1 router-id 10.0.3.3
[R3-ospf-1]area 1
[R3-ospf-1-area-0.0.0.1]network 10.0.3.0 0.0.0.255
[R3-ospf-1-area-0.0.0.1]network 10.0.13.0 0.0.0.255
```

步骤三. OSPF 路由验证

查看R1、R2和R3的路由表，确认各路由器已学习到如下灰色突出显示部分的路由条目。

```
[R1]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
       Destinations : 2       Routes : 2

OSPF routing table status : <Active>
       Destinations : 2       Routes : 2

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface
```

```
10.0.2.2/32  OSPF   10   1562        D   10.0.12.2       Serial1/0/0
10.0.3.3/32  OSPF   10   1           D   10.0.13.3       GigabitEthernet0/0/0
OSPF routing table status : <Inactive>
       Destinations : 0       Routes : 0

[R2]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
----------------------------------------------------------------------------
Public routing table : OSPF
       Destinations : 3       Routes : 3

OSPF routing table status : <Active>
       Destinations : 3       Routes : 3

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

     10.0.1.1/32  OSPF   10   1562        D   10.0.12.1       Serial1/0/0
     10.0.3.3/32  OSPF   10   1563        D   10.0.12.1       Serial1/0/0
    10.0.13.0/24  OSPF   10   1563        D   10.0.12.1       Serial1/0/0

OSPF routing table status : <Inactive>
       Destinations : 0       Routes : 0

[R3]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
----------------------------------------------------------------------------
Public routing table : OSPF
       Destinations : 3       Routes : 3

OSPF routing table status : <Active>
       Destinations : 3       Routes : 3

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

10.0.1.1/32  OSPF   10   1           D   10.0.13.1       GigabitEthernet0/0/0
10.0.2.2/32  OSPF   10   1563        D   10.0.13.1       GigabitEthernet0/0/0
10.0.12.0/24  OSPF   10   1563        D   10.0.13.1       GigabitEthernet0/0/0

OSPF routing table status : <Inactive>
       Destinations : 0       Routes : 0
```

在R3上测试网络连通性。

```
[R3]ping 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=255 time=3 ms
    Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=255 time=2 ms
    Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=255 time=2 ms
    Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=255 time=2 ms
    Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=255 time=2 ms

--- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 2/2/3 ms

[R3]ping 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.2.2: bytes=56 Sequence=1 ttl=254 time=32 ms
    Reply from 10.0.2.2: bytes=56 Sequence=2 ttl=254 time=37 ms
    Reply from 10.0.2.2: bytes=56 Sequence=3 ttl=254 time=37 ms
    Reply from 10.0.2.2: bytes=56 Sequence=4 ttl=254 time=37 ms
    Reply from 10.0.2.2: bytes=56 Sequence=5 ttl=254 time=37 ms

--- 10.0.2.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 32/36/37 ms
```

查看OSPF邻居状态。

```
[R1]display ospf peer brief

         OSPF Process 1 with Router ID 10.0.1.1
                  Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id          Interface                      Neighbor id      State
 0.0.0.0          Serial1/0/0                     10.0.2.2        Full
 0.0.0.1          GigabitEthernet0/0/0            10.0.3.3        Full
 ----------------------------------------------------------------------------

[R2]display ospf peer brief

         OSPF Process 1 with Router ID 10.0.2.2
                  Peer Statistic Information
```

```
----------------------------------------------------------------------------
Area Id        Interface                     Neighbor id     State
0.0.0.0        Serial1/0/0                    10.0.1.1       Full
----------------------------------------------------------------------------

[R3]display ospf peer brief

       OSPF Process 1 with Router ID 10.0.3.3
               Peer Statistic Information
----------------------------------------------------------------------------
Area Id        Interface                     Neighbor id     State
0.0.0.1        GigabitEthernet0/0/0            10.0.1.1       Full
----------------------------------------------------------------------------
```

确认以上各路由器OSPF进程号和Router ID正确，且邻居关系全部达到**full**状态。

步骤四. OSPF 外部路由引入及验证

在R3上使用**import-route**命令引入直连外部路由。

```
[R3]ospf 1
[R3-ospf-1]import-route direct
```

查看R1和R2的路由表，确认已学到引入的路由10.0.3.0/24和172.16.0.0/24。

```
[R1]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
----------------------------------------------------------------------------
Public routing table : OSPF
       Destinations : 4      Routes : 4

OSPF routing table status : <Active>
       Destinations : 4      Routes : 4

Destination/Mask    Proto   Pre  Cost Flags    NextHop     Interface
10.0.2.2/32  OSPF   10   1562      D      10.0.12.2     Serial1/0/0
10.0.3.0/24  O_ASE  150    1       D      10.0.13.3      GigabitEthernet0/0/0
10.0.3.3/32  OSPF   10     1       D      10.0.13.3      GigabitEthernet0/0/0
172.16.0.0/24  O_ASE  150  1       D      10.0.13.3      GigabitEthernet0/0/0
OSPF routing table status : <Inactive>
       Destinations : 0      Routes : 0
```

```
[R2]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
        Destinations : 5       Routes : 5

OSPF routing table status : <Active>
        Destinations : 5       Routes : 5

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface
      10.0.1.1/32  OSPF    10   1562        D   10.0.12.1       Serial1/0/0
      10.0.3.0/24  O_ASE   150  1           D   10.0.12.1       Serial1/0/0
      10.0.3.3/32  OSPF    10   1563        D   10.0.12.1       Serial1/0/0
     10.0.13.0/24  OSPF    10   1563        D   10.0.12.1       Serial1/0/0
    172.16.0.0/24  O_ASE   150  1           D   10.0.12.1       Serial1/0/0

OSPF routing table status : <Inactive>
        Destinations : 0       Routes : 0
```

以上灰色突出显示为引入的外部路由，Proto字段为**O_ASE**表示OSPF外部路由。

使用带源参数的**ping**命令测试网络的连通性。

```
[R2]ping -a 10.0.2.2 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=254 time=35 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=254 time=33 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=254 time=33 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=254 time=33 ms
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=254 time=33 ms

--- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 33/33/35 ms

[R2]ping -a 10.0.2.2 172.16.0.1
  PING 172.16.0.1: 56  data bytes, press CTRL_C to break
    Reply from 172.16.0.1: bytes=56 Sequence=1 ttl=254 time=35 ms
    Reply from 172.16.0.1: bytes=56 Sequence=2 ttl=254 time=33 ms
    Reply from 172.16.0.1: bytes=56 Sequence=3 ttl=254 time=33 ms
```

```
    Reply from 172.16.0.1: bytes=56 Sequence=4 ttl=254 time=33 ms
    Reply from 172.16.0.1: bytes=56 Sequence=5 ttl=254 time=33 ms

--- 172.16.0.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 33/33/35 ms
```

使用**display ospf lsdb**命令查看R1的链路状态数据库。

```
[R1]display ospf lsdb
         OSPF Process 1 with Router ID 10.0.1.1
                 Link State Database

                        Area: 0.0.0.0
 Type      LinkState ID    AdvRouter          Age  Len   Sequence   Metric
 Router    10.0.2.2        10.0.2.2           908  60    80000003    1562
 Router    10.0.1.1        10.0.1.1           918  48    80000003    1562
 Sum-Net   10.0.13.0       10.0.1.1          1022  28    80000001       1
 Sum-Net   10.0.3.3        10.0.1.1           720  28    80000001       1
 Sum-Net   10.0.1.1        10.0.1.1          1016  28    80000001       0
 Sum-Asbr  10.0.3.3        10.0.1.1           393  28    80000001       1

                         Area: 0.0.0.1
 Type      LinkState ID    AdvRouter          Age  Len   Sequence   Metric
 Router    10.0.3.3        10.0.3.3           394  48    80000005       1
 Router    10.0.1.1        10.0.1.1           719  48    80000006       1
 Network   10.0.13.1       10.0.1.1           719  32    80000002       0
 Sum-Net   10.0.12.0       10.0.1.1          1022  28    80000001    1562
 Sum-Net   10.0.2.2        10.0.1.1           908  28    80000001    1562

                 AS External Database
 Type      LinkState ID    AdvRouter          Age  Len   Sequence   Metric
 External  10.0.3.0        10.0.3.3           395  36    80000001       1
 External  10.0.13.0       10.0.3.3           395  36    80000001       1
 External  172.16.0.0      10.0.3.3           395  36    80000001       1
```

以上显示的是整个链路状态数据库的简要信息。突出显示的内容为LSA Type4和LSA Type5。

也可以使用如下命令显示某个条目的具体信息，以下三条命令分别显示了LSA Type3、4、5三种类型的LSA数据结构。

```
[R1]display ospf lsdb summary 10.0.3.3
```

```
       OSPF Process 1 with Router ID 10.0.1.1
                    Area: 0.0.0.0
             Link State Database


 Type      : Sum-Net
 Ls id     : 10.0.3.3
 Adv rtr   : 10.0.1.1
 Ls age    : 869
 Len       : 28
 Options   :  E
 seq#      : 80000001
 chksum    : 0x4cf3
 Net mask  : 255.255.255.255
 Tos 0  metric: 1
 Priority  : Low
                    Area: 0.0.0.1
             Link State Database


[R1]display ospf lsdb asbr

       OSPF Process 1 with Router ID 10.0.1.1
                    Area: 0.0.0.0
             Link State Database

 Type      : Sum-Asbr
 Ls id     : 10.0.3.3
 Adv rtr   : 10.0.1.1
 Ls age    : 591
 Len       : 28
 Options   :  E
 seq#      : 80000001
 chksum    : 0x3e01
 Tos 0  metric: 1
                    Area: 0.0.0.1
             Link State Database


 [R1]display ospf lsdb ase 172.16.0.0

       OSPF Process 1 with Router ID 10.0.1.1
```

```
              Link State Database

 Type      : External
 Ls id     : 172.16.0.0
 Adv rtr   : 10.0.3.3
 Ls age    : 607
 Len       : 36
 Options   :  E
 seq#      : 80000001
 chksum    : 0xf70c
 Net mask  : 255.255.255.0
 TOS 0  Metric: 1
 E type    : 2
 Forwarding Address : 0.0.0.0
 Tag       : 1
 Priority  : Low
```

步骤五. OSPF 认证配置及验证

将R1接口S1/0/0配置为OSPF接口认证模式，明文，密码为“huawei”。

```
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ospf authentication-mode simple plain huawei
```

在R1上查看与R2的邻居状态。

```
[R1]display ospf peer brief

       OSPF Process 1 with Router ID 10.0.1.1
              Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id          Interface                     Neighbor id      State
 0.0.0.1          GigabitEthernet0/0/0            10.0.3.3         Full
 ----------------------------------------------------------------------------
```

由于此时R1与R2的OSPF认证方式不匹配，所以R1与R2无法建立邻居。

将R2接口S1/0/0配置为OSPF接口认证模式，明文，密码为“huawei”。

```
[R2]interface Serial 1/0/0
[R2-Serial1/0/0]ospf authentication-mode simple plain huawei
```

在R1上查看与R2的邻居状态。

```
[R1]display ospf peer brief

       OSPF Process 1 with Router ID 10.0.1.1
              Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id         Interface                     Neighbor id      State
 0.0.0.0         Serial1/0/0                    10.0.2.2        Full
 0.0.0.1         GigabitEthernet0/0/0            10.0.3.3        Full
 ----------------------------------------------------------------------------
```

此时R1与R2之间认证方式和密码均匹配，所以R1与R2重新建立了邻居关系。

将R1的区域1配置为OSPF区域认证模式，加密方式为MD5，密码为密文形式“huawei”。

```
[R1]ospf 1
[R1-ospf-1]area 1
[R1-ospf-1-area-0.0.0.1]authentication-mode md5 1 cipher huawei
```

在R1上查看与R3的邻居状态。

```
[R1]display ospf peer brief

       OSPF Process 1 with Router ID 10.0.1.1
              Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id         Interface                     Neighbor id      State
 0.0.0.0         Serial1/0/0                    10.0.2.2        Full
----------------------------------------------------------------------------
```

由于R1与R3之间OSPF认证方式不匹配，此时R1与R3无法建立邻居关系。

将R3上区域1配置为OSPF区域认证模式，加密方式为MD5，密码为密文形式“huawei”。

```
[R3]ospf 1
[R3-ospf-1]area 1
[R3-ospf-1-area-0.0.0.2]authentication-mode md5 1 cipher huawei
```

在R1上查看与R3的邻居状态。

```
[R1]display ospf peer brief

       OSPF Process 1 with Router ID 10.0.1.1
              Peer Statistic Information
 ----------------------------------------------------------------------------
```

```
Area Id         Interface                        Neighbor id      State
0.0.0.0         Serial1/0/0                      10.0.2.2         Full
0.0.0.1         GigabitEthernet0/0/0             10.0.3.3         Full
----------------------------------------------------------------------------
```

此时R1与R3之间认证方式和密码均匹配，所以R1与R3重新建立了邻居关系。

附加实验：思考并验证

对于步骤四中出现的以下信息。

```
10.0.3.0/24  O_ASE   150  1          D   10.0.12.1      Serial1/0/0
10.0.3.3/32  OSPF    10   1563       D   10.0.12.1      Serial1/0/0
```

这两条路由的起源是R3的环回口0，但是单一接口导致其他路由器学到了两条路由，这样会有什么问题？如何解决？

分析LSA Type4的产生、传输和转化情况。

最终设备配置

```
[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.1 255.255.255.0
 ospf authentication-mode simple plain huawei
#
interface GigabitEthernet0/0/0
 ip address 10.0.13.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
ospf 1 router-id 10.0.1.1
 area 0.0.0.0
  network 10.0.12.0 0.0.0.255
 area 0.0.0.1
  authentication-mode md5 1 cipher gg^dP=F.[>=H)H2[EInB~.2#
  network 10.0.13.0 0.0.0.255
  network 10.0.1.0 0.0.0.255
```

```
#
return

[R2]display current-configuration
[V200R001C01SPC300]
#
sysname R2
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.2 255.255.255.0
 ospf authentication-mode simple plain huawei
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
ospf 1 router-id 10.0.2.2
 area 0.0.0.0
  network 10.0.12.0 0.0.0.255
  network 10.0.2.0 0.0.0.255
#
return

[R3]display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
interface GigabitEthernet0/0/0
 ip address 10.0.13.3 255.255.255.0
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
interface LoopBack2
 ip address 172.16.0.1 255.255.255.0
#
ospf 1 router-id 10.0.3.3
 import-route direct
 area 0.0.0.1
  authentication-mode md5 1 cipher gg^dP=F.[>=H)H2[EInB~.2#
  network 10.0.3.0 0.0.0.255
  network 10.0.13.0 0.0.0.255
```

```
#
return
```

第五章 RIP、OSPF相互引入路由

实验 5-1 RIP、OSPF 相互引入路由

学习目的

- 理解路由相互引入的意义
- 掌握从OSPF向RIP注入路由的方法
- 掌握从RIP向OSPF注入路由的方法

拓扑图

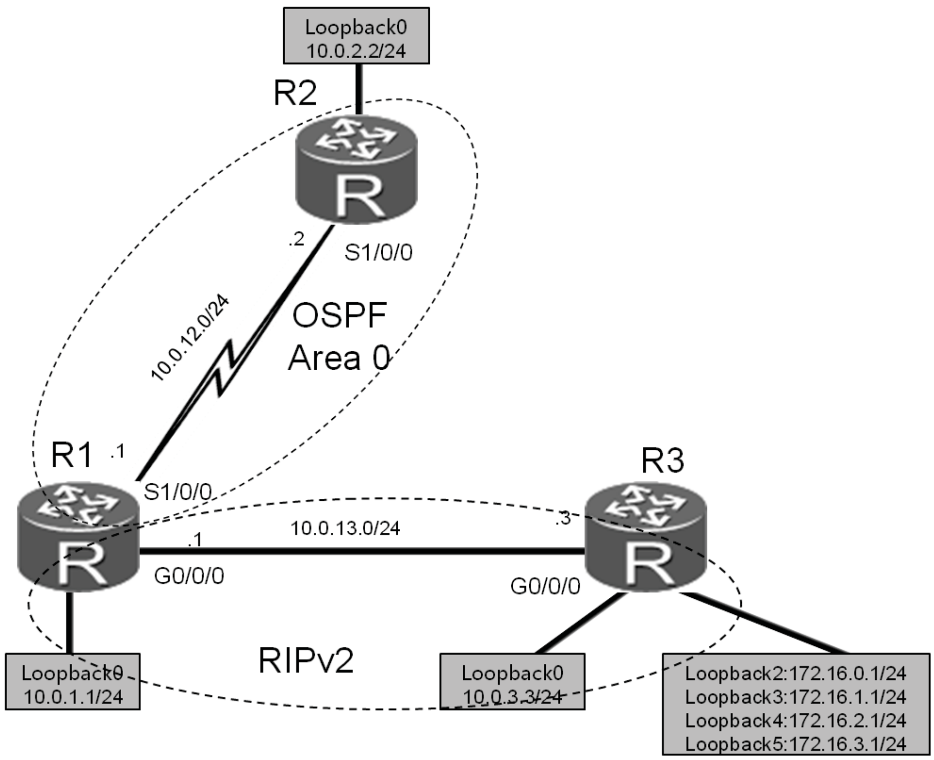


图5.1 RIP、OSPF相互引入路由实验拓扑图

场景

你是你们公司的网络管理员。当前公司网络同时使用了RIPv2和OSPF协议。为了实现RIP区域设备与OSPF区域设备之间的互通。你需要配置路由的相互引入操作。配置时需要注意不同路由协议度量值定义的标准。

学习任务

步骤一.　基本配置与 IP 编址

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface serial 1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 24
[R1-Serial1/0/0]interface GigabitEthernet 0/0/0
[R1-GigabitEthernet0/0/0]ip address 10.0.13.1 24
[R1-GigabitEthernet0/0/0]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface serial1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 24
[R2-Serial1/0/0]interface loopback 0
[R2-LoopBack0]ip address 10.0.2.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/0
[R3-GigabitEthernet0/0/0]ip address 10.0.13.3 24
[R3-GigabitEthernet0/0/0]interface loopback 0
[R3-LoopBack0]ip address 10.0.3.3 24
[R3-LoopBack0]interface loopback 2
[R3-LoopBack2]ip address 172.16.0.1 24
[R3-LoopBack2]interface LoopBack 3
[R3-LoopBack3]ip address 172.16.1.1 24
[R3-LoopBack3]interface LoopBack 4
[R3-LoopBack4]ip address 172.16.2.1 24
```

```
[R3-LoopBack4]interface LoopBack 5
[R3-LoopBack5]ip address 172.16.3.1 24
```

步骤二. OSPF 协议配置及验证

R1与R2之间运行OSPF，配置属于Area0。

```
[R1]ospf 1 router-id 10.0.1.1
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255

[R2]ospf 1 router-id 10.0.2.2
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0]network 10.0.12.0 0.0.0.255
[R2-ospf-1-area-0.0.0.0]network 10.0.2.0 0.0.0.255
```

查看R1和R2的路由表，确认已通过OSPF学习其他网段的路由。

```
[R1]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
----------------------------------------------------------------------------
Public routing table : OSPF
        Destinations : 1        Routes : 1

OSPF routing table status : <Active>
        Destinations : 1        Routes : 1

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

      10.0.2.2/32  OSPF    10   1562       D   10.0.12.2      Serial1/0/0

OSPF routing table status : <Inactive>
        Destinations : 0        Routes : 0

[R2]display ip routing-table protocol ospf
[R2]
```

OSPF区域的网络都与R2直接相连，所以R2未通过OSPF学到额外的路由信息。

步骤三. RIPv2 协议配置及验证

在R1上开启RIP协议进程，配置使用版本号为2。将10.0.0.0网段通告进RIP路由进程。

```
[R1]rip 1
[R1-rip-1]version 2
[R1-rip-1]network 10.0.0.0
```

在R3上开启RIP协议进程，配置使用版本号为2，将172.16.0.0和10.0.0.0两个网段通告进RIP路由进程。

```
[R3]rip 1
[R3-rip-1]version 2
[R3-rip-1]network 10.0.0.0
[R3-rip-1]network 172.16.0.0
```

查看R1和R3的路由表，确认路由器已经通过RIP学习到相应的路由。

```
[R1]display ip routing-table protocol rip
Route Flags: R - relay, D - download to fib
----------------------------------------------------------------------------
Public routing table : RIP
       Destinations : 5       Routes : 5

RIP routing table status : <Active>
       Destinations : 5       Routes : 5

Destination/Mask   Proto  Pre  Cost     Flags NextHop       Interface
10.0.3.0/24    RIP    100  1         D   10.0.13.3      GigabitEthernet0/0/0
172.16.0.0/24  RIP    100  1         D   10.0.13.3      GigabitEthernet0/0/0
172.16.1.0/24  RIP    100  1         D   10.0.13.3      GigabitEthernet0/0/0
172.16.2.0/24  RIP    100  1         D   10.0.13.3      GigabitEthernet0/0/0
172.16.3.0/24  RIP    100  1         D   10.0.13.3      GigabitEthernet0/0/0

RIP routing table status : <Inactive>
       Destinations : 0       Routes : 0

[R3]display ip routing-table protocol rip
Route Flags: R - relay, D - download to fib
----------------------------------------------------------------------------
Public routing table : RIP
       Destinations : 2       Routes : 2
```

```
RIP routing table status : <Active>
        Destinations : 2       Routes : 2

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface
10.0.1.0/24  RIP     100  1         D   10.0.13.1      GigabitEthernet0/0/0
10.0.12.0/24  RIP     100  1         D   10.0.13.1      GigabitEthernet0/0/0

RIP routing table status : <Inactive>
        Destinations : 0       Routes : 0
```

步骤四. RIPv2 和 OSPF 协议相互引入配置及验证

到目前为止，R2与R3未学到对方的路由信息，原因是它们不在同一种路由区域。在R1上将RIP学到的路由引入到OSPF路由表中。

```
[R1]ospf 1
[R1-ospf-1]import-route rip 1 cost 100
```

在R1上执行将OSPF路由引入到RIP路由域。

```
[R1]rip 1
[R1-rip-1]import-route ospf 1 cost 1
```

验证R1、R2和R3的路由表，确认学习到的路由。

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 20      Routes : 20

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

      10.0.1.0/24  Direct  0    0    D   10.0.1.1       LoopBack0
      10.0.1.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
    10.0.1.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
      10.0.2.2/32  OSPF    10   1562 D   10.0.12.2      Serial1/0/0
      10.0.3.0/24  RIP     100  1    D   10.0.13.3      GigabitEthernet0/0/0
     10.0.12.0/24  Direct  0    0    D   10.0.12.1      Serial1/0/0
     10.0.12.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.12.2/32  Direct  0    0    D   10.0.12.2      Serial1/0/0
   10.0.12.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
     10.0.13.0/24  Direct  0    0    D   10.0.13.1      GigabitEthernet0/0/0
     10.0.13.1/32  Direct  0    0    D   127.0.0.1      InLoopBack0
```

```
   10.0.13.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0    D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0    D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
    172.16.0.0/24  RIP     100  1    D   10.0.13.3       GigabitEthernet0/0/0
    172.16.1.0/24  RIP     100  1    D   10.0.13.3       GigabitEthernet0/0/0
    172.16.2.0/24  RIP     100  1    D   10.0.13.3       GigabitEthernet0/0/0
    172.16.3.0/24  RIP     100  1    D   10.0.13.3       GigabitEthernet0/0/0
255.255.255.255/32  Direct  0    0    D   127.0.0.1       InLoopBack0
```

R1的路由表与之前比较无变化，原因是R1同时处于OSPF和RIP路由区域，在引入路由之前就已经学习到所有的路由信息了。

确认R2和R3的路由表已经学习到如下路由。

```
[R2]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
         Destinations : 7        Routes : 7

OSPF routing table status : <Active>
         Destinations : 7        Routes : 7

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface


      10.0.1.0/24  O_ASE   150  100         D   10.0.12.1       Serial1/0/0
      10.0.3.0/24  O_ASE   150  100         D   10.0.12.1       Serial1/0/0
     10.0.13.0/24  O_ASE   150  100         D   10.0.12.1       Serial1/0/0
    172.16.0.0/24  O_ASE   150  100         D   10.0.12.1       Serial1/0/0
    172.16.1.0/24  O_ASE   150  100         D   10.0.12.1       Serial1/0/0
    172.16.2.0/24  O_ASE   150  100         D   10.0.12.1       Serial1/0/0
    172.16.3.0/24  O_ASE   150  100         D   10.0.12.1       Serial1/0/0
OSPF routing table status : <Inactive>
         Destinations : 0        Routes : 0

[R3]display ip routing-table protocol rip
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : RIP
         Destinations : 3        Routes : 3

RIP routing table status : <Active>
         Destinations : 3        Routes : 3
```

```
Destination/Mask    Proto   Pre  Cost      Flags NextHop        Interface

      10.0.1.0/24  RIP     100  1     D   10.0.13.1      GigabitEthernet0/0/0
      10.0.2.2/32  RIP     100  2     D   10.0.13.1      GigabitEthernet0/0/0
     10.0.12.0/24  RIP     100  1     D   10.0.13.1      GigabitEthernet0/0/0

RIP routing table status : <Inactive>
        Destinations : 0       Routes : 0
```

测试网络连通性。在R2上使用扩展**ping**命令，定义数据包的源地址，测试到达地址10.0.3.3的连通性。

```
[R2]ping  -a 10.0.2.2 10.0.3.3
 PING 10.0.3.3: 56  data bytes, press CTRL_C to break
   Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=254 time=43 ms
   Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=254 time=41 ms
   Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=254 time=40 ms
   Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=254 time=41 ms
   Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=254 time=41 ms

--- 10.0.3.3 ping statistics ---
   5 packet(s) transmitted
   5 packet(s) received
   0.00% packet loss
   round-trip min/avg/max = 40/41/43 ms

[R2]ping  -a 10.0.2.2 172.16.0.1
  PING 172.16.0.1: 56  data bytes, press CTRL_C to break
   Reply from 172.16.0.1: bytes=56 Sequence=1 ttl=254 time=43 ms
   Reply from 172.16.0.1: bytes=56 Sequence=2 ttl=254 time=42 ms
   Reply from 172.16.0.1: bytes=56 Sequence=3 ttl=254 time=41 ms
   Reply from 172.16.0.1: bytes=56 Sequence=4 ttl=254 time=41 ms
   Reply from 172.16.0.1: bytes=56 Sequence=5 ttl=254 time=41 ms

 --- 172.16.0.1 ping statistics ---
   5 packet(s) transmitted
   5 packet(s) received
   0.00% packet loss
   round-trip min/avg/max = 41/41/43 ms
```

在R3的接口G0/0/0上配置RIP手动路由汇总。

```
[R3]interface GigabitEthernet 0/0/0
[R3-GigabitEthernet0/0/0]rip summary-address 172.16.0.0 255.255.252.0
```

验证R1和R2的路由表，比较与步骤3中显示的路由表的区别。

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
       Destinations : 17      Routes : 17
Destination/Mask   Proto  Pre  Cost     Flags NextHop        Interface

      10.0.1.0/24  Direct  0    0          D   10.0.1.1       LoopBack0
      10.0.1.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
    10.0.1.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
      10.0.2.2/32  OSPF   10   1562        D   10.0.12.2      Serial1/0/0
10.0.3.0/24  RIP    100  1          D   10.0.13.3      GigabitEthernet0/0/0
     10.0.12.0/24  Direct  0    0          D   10.0.12.1      Serial1/0/0
     10.0.12.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
     10.0.12.2/32  Direct  0    0          D   10.0.12.2      Serial1/0/0
   10.0.12.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
10.0.13.0/24  Direct  0    0          D   10.0.13.1      GigabitEthernet0/0/0
     10.0.13.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
   10.0.13.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
     127.0.0.0/8   Direct  0    0          D   127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
172.16.0.0/22  RIP    100  1          D   10.0.13.3      GigabitEthernet0/0/0
255.255.255.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0

[R2]display ip routing-table protocol ospf
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : OSPF
       Destinations : 4       Routes : 4

OSPF routing table status : <Active>
       Destinations : 4       Routes : 4

Destination/Mask   Proto  Pre  Cost     Flags NextHop        Interface

      10.0.1.0/24  O_ASE   150  100        D   10.0.12.1      Serial1/0/0
      10.0.3.0/24  O_ASE   150  100        D   10.0.12.1      Serial1/0/0
     10.0.13.0/24  O_ASE   150  100        D   10.0.12.1      Serial1/0/0
    172.16.0.0/22  O_ASE   150  100        D   10.0.12.1      Serial1/0/0
OSPF routing table status : <Inactive>
```

```
        Destinations : 0        Routes : 0
```

此时R1和R2学到的路由是汇总路由172.16.0.0/22，而不再是明细路由172.16.0.0/24等。

附加实验：思考并验证

从其他路由协议引入的路由被称为外部路由。OSPF和RIP分别用什么方式来标识外部路由？外部路由相对于协议自己学到的路由，有什么差异？哪种路由信息更加可靠？

是否可以把汇总的操作放在R1上进行？

路由引入时，我们均采用了缺省配置。以将RIP路由引入到OSPF为例，有哪些参数可选？分别是什么作用？

最终设备配置

```
[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.1 255.255.255.0
#
interface GigabitEthernet0/0/0
 ip address 10.0.13.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
ospf 1 router-id 10.0.1.1
 import-route rip 1 cost 100
 area 0.0.0.0
  network 10.0.12.0 0.0.0.255
#
rip 1
 version 2
 network 10.0.0.0
 import-route ospf 1 cost 1
#
```

```
return

[R2]display current-configuration
[V200R001C01SPC300]
#
 sysname R2
#
interface Serial1/0/0
 link-protocol ppp
 ip address 10.0.12.2 255.255.255.0
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
ospf 1 router-id 10.0.2.2
 area 0.0.0.0
  network 10.0.12.0 0.0.0.255
  network 10.0.2.0 0.0.0.255
#
return

[R3]display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
interface GigabitEthernet0/0/0
 ip address 10.0.13.3 255.255.255.0
 rip summary-address 172.16.0.0 255.255.252.0
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
interface LoopBack2
 ip address 172.16.0.1 255.255.255.0
#
interface LoopBack3
 ip address 172.16.1.1 255.255.255.0
#
interface LoopBack4
 ip address 172.16.2.1 255.255.255.0
#
interface LoopBack5
```

```
 ip address 172.16.3.1 255.255.255.0
#
rip 1
 version 2
 network 10.0.0.0
 network 172.16.0.0
#
return
```

第六章 以太网及生成树协议

实验 6-1 以太网接口及链路配置

学习目的

- 了解以太网接口的各种统计信息
- 理解速度和双工的意义
- 掌握以太网接口速度和双工的配置
- 掌握交换机之间手动链路聚合的方法

拓扑图

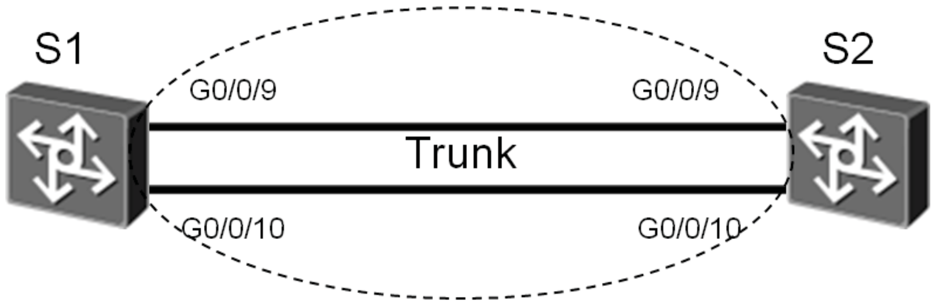


图6.1 交换基础实验拓扑图

场景

你是公司的网络管理员。现在公司购买了两台华为的S5700系列的交换机，需要你先进行调试。你决定对双工和速度方面进行技术测试。

学习任务

步骤一.　以太网交换机基本操作

华为交换机接口默认设置为自动协商速率和双工模式，在本任务中，我们将S1和S2的G0/0/9和G0/0/10接口的速率和双工改为手动设置模式。

更改系统名称，查看S1的G0/0/9和G0/0/10接口详细信息。

```
<Quidway>system-view
[Quidway]sysname S1
[S1]display interface GigabitEthernet 0/0/9
GigabitEthernet0/0/9 current state : UP
Line protocol current state : UP
Description:HUAWEI, Quidway Series, GigabitEthernet0/0/9 Interface
Switch Port,PVID :    1,The Maximum Frame Length is 1600
IP Sending Frames' Format is PKTFMT_ETHNT_2, Hardware address is 0018-82e1-aea6
Port Mode: COMMON COPPER
Speed : 1000,  Loopback: NONE
Duplex: FULL,  Negotiation: ENABLE
Mdi   : AUTO
Last 300 seconds input rate 752 bits/sec, 0 packets/sec
Last 300 seconds output rate 720 bits/sec, 0 packets/sec
Input peak rate 1057259144 bits/sec,Record time: 2008-10-01 00:08:58
Output peak rate 1057267232 bits/sec,Record time: 2008-10-01 00:08:58
Input:  11655141 packets, 960068100 bytes
Unicast       :                70,Multicast         :            5011357
Broadcast     :           6643714,Jumbo             :                  0
CRC          :                 0,Giants           :                 0
Jabbers       :                 0,Throttles         :                 0
Runts        :                  0,DropEvents        :                 0
Alignments     :                0,Symbols           :                 0
Ignoreds      :                 0,Frames            :                 0
Discard       :                69,Total Error       :                 0
Output: 11652169 packets, 959869843 bytes
Unicast       :               345,Multicast         :            5009016
Broadcast     :           6642808,Jumbo             :                  0
Collisions     :                0,Deferreds         :                 0
Late Collisions:                0,ExcessiveCollisions:                 0
Buffers Purged :                0
Discard       :                 5,Total Error       :                 0
   Input bandwidth utilization threshold : 100.00%
   Output bandwidth utilization threshold: 100.00%
```

```
   Input bandwidth utilization  : 0.01%
   Output bandwidth utilization : 0.00%

[S1]display interface GigabitEthernet 0/0/10
GigabitEthernet0/0/10 current state : UP
Line protocol current state : UP
Description:HUAWEI, Quidway Series, GigabitEthernet0/0/10 Interface
Switch Port,PVID :    1,The Maximum Frame Length is 1600
IP Sending Frames' Format is PKTFMT_ETHNT_2, Hardware address is 0018-82e1-aea6
Port Mode: COMMON COPPER
Speed : 1000,  Loopback: NONE
Duplex: FULL,  Negotiation: ENABLE
Mdi   : AUTO
Last 300 seconds input rate 1312 bits/sec, 0 packets/sec
Last 300 seconds output rate 72 bits/sec, 0 packets/sec
Input peak rate 1057256792 bits/sec,Record time: 2008-10-01 00:08:58
Output peak rate 1057267296 bits/sec,Record time: 2008-10-01 00:08:58
Input:  11651829 packets, 959852817 bytes
Unicast       :               115,Multicast        :            5009062
Broadcast     :           6642648,Jumbo            :                  0
CRC          :                  3,Giants          :                  0
Jabbers       :                 0,Throttles        :                  0
Runts        :                  0,DropEvents       :                  0
Alignments    :                 0,Symbols          :                  4
Ignoreds      :                 0,Frames           :                  0
Discard       :               218,Total Error      :                  7
Output: 11655280 packets, 960072712 bytes
Unicast       :               245,Multicast        :            5011284
Broadcast     :           6643751,Jumbo            :                  0
Collisions    :                 0,Deferreds        :                  0
Late Collisions:                0,ExcessiveCollisions:                  0
Buffers Purged :                0
Discard       :               107,Total Error      :                  0
   Input bandwidth utilization threshold : 100.00%
   Output bandwidth utilization threshold: 100.00%
   Input bandwidth utilization  : 0.01%
   Output bandwidth utilization : 0.00%
```

将S1的G0/0/9和G0/0/10接口设置为100M速率和全双工模式。

```
[S1]interface GigabitEthernet 0/0/9
 [S1-GigabitEthernet0/0/9]undo negotiation auto
[S1-GigabitEthernet0/0/9]speed 100
[S1-GigabitEthernet0/0/9]duplex full
```

```
[S1-GigabitEthernet0/0/9]quit
[S1]interface GigabitEthernet 0/0/10
[S1-GigabitEthernet0/0/10]undo negotiation auto
[S1-GigabitEthernet0/0/10]speed 100
[S1-GigabitEthernet0/0/10]duplex full
```

更改接口的速率和双工模式之前应先关闭接口的自动协商功能。

将S2的G0/0/9和G0/0/10接口设置为100M速率和全双工模式。

```
<Quidway>system-view
[Quidway]sysname S2
[S2]interface GigabitEthernet 0/0/9
[S2-GigabitEthernet0/0/9]undo negotiation auto
[S2-GigabitEthernet0/0/9]speed 100
[S2-GigabitEthernet0/0/9]duplex full
[S2-GigabitEthernet0/0/9]quit
[S2]interface GigabitEthernet 0/0/10
[S2-GigabitEthernet0/0/10]undo negotiation auto
[S2-GigabitEthernet0/0/10]speed 100
[S2-GigabitEthernet0/0/10]duplex full
```

验证S1接口G0/0/9和G0/0/10的速率和双工模式。

```
[S1]display interface GigabitEthernet 0/0/9
GigabitEthernet0/0/9 current state : UP
Line protocol current state : UP
Description:HUAWEI, Quidway Series, GigabitEthernet0/0/9 Interface
Switch Port,PVID :    1,The Maximum Frame Length is 1600
IP Sending Frames' Format is PKTFMT_ETHNT_2, Hardware address is 0018-82e1-aea6
Port Mode: COMMON COPPER
Speed :  100,  Loopback: NONE
Duplex: FULL,  Negotiation: DISABLE
Mdi   : AUTO
……output omit……

[S1]display interface GigabitEthernet 0/0/10
GigabitEthernet0/0/10 current state : UP
Line protocol current state : UP
Description:HUAWEI, Quidway Series, GigabitEthernet0/0/10 Interface
Switch Port,PVID :    1,The Maximum Frame Length is 1600
IP Sending Frames' Format is PKTFMT_ETHNT_2, Hardware address is 0018-82e1-aea6
Port Mode: COMMON COPPER
Speed :  100,  Loopback: NONE
```

```
Duplex: FULL,  Negotiation: DISABLE
Mdi   : AUTO
……output omit……
```

步骤二.　配置手动链路聚合。

在S1、S2上创建Eth-trunk 1。清除S1和S2的G0/0/9和G0/0/10接口上的默认配置后将其加入Eth-trunk 1。

```
[S1]interface Eth-Trunk 1
[S1-Eth-Trunk1]quit
[S1]interface GigabitEthernet 0/0/9
[S1-GigabitEthernet0/0/9]eth-trunk 1
[S1-GigabitEthernet0/0/9]int GigabitEthernet 0/0/10
[S1-GigabitEthernet0/0/10]eth-trunk 1

[S2]interface Eth-Trunk 1
[S2-Eth-Trunk1]quit
[S2]interface GigabitEthernet 0/0/9
[S2-GigabitEthernet0/0/9]eth-trunk 1
[S2-GigabitEthernet0/0/9]interface GigabitEthernet 0/0/10
[S2-GigabitEthernet0/0/10]eth-trunk 1
```

Eth-trunk配置结果验证。

```
[S1]display eth-trunk 1
Eth-Trunk1's state information is:
WorkingMode: NORMAL        Hash arithmetic: According to MAC
Least Active-linknumber: 1  Max Bandwidth-affected-linknumber: 8
Operate status: up         Number Of Up Port In Trunk: 2
----------------------------------------------------------------------------
PortName                      Status     Weight
GigabitEthernet0/0/9            Up          1
GigabitEthernet0/0/10           Up          1

[S2]display eth-trunk 1
Eth-Trunk1's state information is:
WorkingMode: NORMAL        Hash arithmetic: According to MAC
Least Active-linknumber: 1  Max Bandwidth-affected-linknumber: 8
Operate status: up         Number Of Up Port In Trunk: 2
----------------------------------------------------------------------------
PortName                      Status     Weight
GigabitEthernet0/0/9            Up          1
```

```
GigabitEthernet0/0/10         Up          1
```

由以上输出可以看出，配置的eth-trunk处于正常工作状态。

附加实验：思考并验证

在产品手册中查找资料，了解设备在进行双工和速度方面的自动协商时，使用什么协议？工作机理是怎样的？

最终设备配置

```
[S1]display current-configuration
#
!Software Version V100R006C00SPC800
 sysname S1
#
interface Eth-Trunk1
#
interface GigabitEthernet0/0/9
 eth-trunk 1
 undo negotiation auto
 speed 100
#
interface GigabitEthernet0/0/10
 eth-trunk 1
 undo negotiation auto
 speed 100
#
return

[S2]display current-configuration
#
!Software Version V100R006C00SPC800
 sysname S2
#
interface Eth-Trunk1
#
interface GigabitEthernet0/0/9
 eth-trunk 1
 undo negotiation auto
 speed 100
#
```

```
interface GigabitEthernet0/0/10
 eth-trunk 1
 undo negotiation auto
 speed 100
#
return
```

实验 6-2 STP 配置

学习目的

- 掌握启用和关闭STP的方法
- 了解不同的STP模式的差异
- 掌握修改网桥优先级影响根网桥选举的方法
- 掌握修改端口优先级影响根端口与指定端口选举的方法
- 掌握配置边缘端口的方法

拓扑图

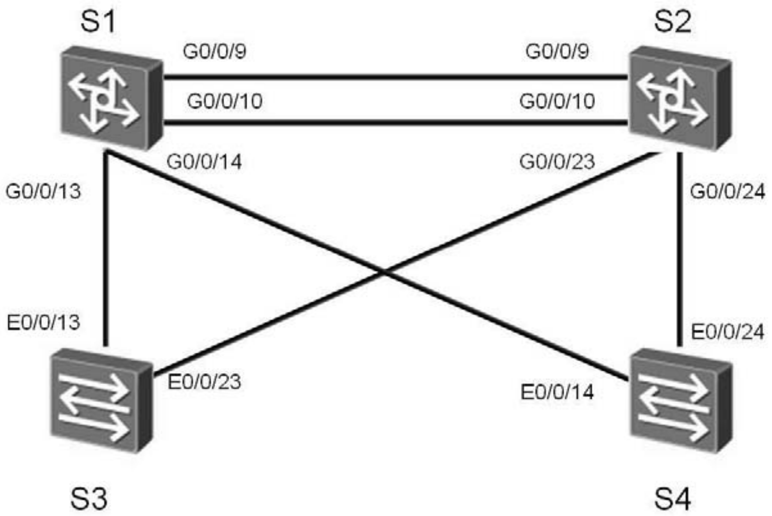


图6.2 STP实验拓扑图

场景

你是公司的网络管理员。公司的网络使用了两层网络结构，核心层和接入层。采用了冗余网络，为避免存在的环路问题，你决定使用STP来进行环路控制。STP有不同的模式，也可以对STP的根桥等进行控制。同样为了加快边缘网络的收敛

速度，也可以使用一些特性来配置STP。

学习任务

步骤一. STP 配置及验证

实验之前，关闭S3的接口E0/0/1，以避免对实验的影响。

请保证设备以空配置启动。如果设备默认生成树没有开启，使用**stp enable**命令开启。

本次实验中，我们使用传统生成树。

```
<Quidway>system-view
Enter system view, return user view with Ctrl+Z.
[Quidway]sysname S1
[S1]stp mode stp
[S1]stp root secondary


<Quidway>system-view
Enter system view, return user view with Ctrl+Z.
[Quidway]sysname S2
[S2]stp mode stp
[S2]stp root primary

<Quidway>system-view
Enter system view, return user view with Ctrl+Z.
[Quidway]sysname S3
[S3]stp mode stp

<Quidway>system-view
Enter system view, return user view with Ctrl+Z.
[Quidway]sysname S4
[S4]stp mode stp
```

使用**display stp brief**命令查看各接口简要STP状态。

```
[S1]display stp brief
 MSTID  Port                    Role  STP State     Protection
  0     GigabitEthernet0/0/9    ROOT  FORWARDING      NONE
  0     GigabitEthernet0/0/10   ALTE  DISCARDING      NONE
  0     GigabitEthernet0/0/13   DESI  FORWARDING      NONE
  0     GigabitEthernet0/0/14   DESI  FORWARDING      NONE
```

```
[S2]display stp brief
 MSTID  Port                        Role  STP State     Protection
   0    GigabitEthernet0/0/9         DESI  FORWARDING      NONE
   0    GigabitEthernet0/0/10        DESI  FORWARDING      NONE
   0    GigabitEthernet0/0/23        DESI  FORWARDING      NONE
   0    GigabitEthernet0/0/24        DESI  FORWARDING      NONE

[S3]display stp brief
 MSTID  Port                        Role  STP State     Protection
   0    Ethernet0/0/13               ALTE  DISCARDING      NONE
   0    Ethernet0/0/23               ROOT  FORWARDING      NONE

[S4]display stp brief
 MSTID  Port                        Role  STP State     Protection
   0    Ethernet0/0/14               ALTE  DISCARDING      NONE
   0    Ethernet0/0/24               ROOT  FORWARDING      NONE
```

使用**display stp interface**命令查看某接口详细STP状态。

```
[S1]display stp interface GigabitEthernet 0/0/10
----[CIST][Port10(GigabitEthernet0/0/10)][DISCARDING]----
 Port Protocol       :enabled
 Port Role          :Alternate Port
 Port Priority       :128
 Port Cost(Dot1T )   :Config=auto / Active=20000
 Desg. Bridge/Port   :0.0018-82e1-aea6 / 128.10
 Port Edged         :Config=default / Active=disabled
 Point-to-point      :Config=auto / Active=true
 Transit Limit       :147 packets/hello-time
 Protection Type     :None
 Port Stp Mode       :STP
 Port Protocol Type  :Config=auto / Active=dot1s
 PortTimes          :Hello 2s MaxAge 20s FwDly 15s RemHop 0
 TC or TCN send  :2
 TC or TCN received  :64
 BPDU Sent          :24
        TCN: 0, Config: 0, RST: 24, MST: 0
 BPDU Received       :350601
        TCN: 0, Config: 0, RST: 350601, MST: 0
```

步骤二.　根桥选举控制

使用**display stp**命令查看当前根桥信息。

```
[S2]display stp
-------[CIST Global Info][Mode STP]-------
CIST Bridge         :0    .0018-82e1-aea6
Bridge Times        :Hello 2s MaxAge 20s FwDly 15s MaxHop 20
CIST Root/ERPC      :0    .0018-82e1-aea6 / 0
CIST RegRoot/IRPC   :0    .0018-82e1-aea6 / 0
CIST RootPortId     :0.0
BPDU-Protection     :disabled
CIST Root Type      :PRIMARY root
TC or TCN received  :41
TC count per hello  :0
STP Converge Mode   :Nomal
Time since last TC :0 days 0h:1m:6s
……output omit……
```

实验中特别定义了S2为主根网桥，S1为备份根网桥。如上输出"CIST Bridge"和"CIST Root/ERPC"字段值相同的即为根桥。

桥优先级数值越小的优先级越高，因此将S1的桥优先级修改为4096，将S2的桥优先级修改为8192，S1的优先级高于S2，S1将选举为根桥。

```
[S1]undo stp root
[S1]stp priority 4096

[S2]undo stp root
[S2]stp priority 8192
```

使用**display stp**命令查看新的根桥信息。

```
[S1]display stp
-------[CIST Global Info][Mode STP]-------
CIST Bridge         :4096 .0018-82e1-aea6
Bridge Times        :Hello 2s MaxAge 20s FwDly 15s MaxHop 20
CIST Root/ERPC      :4096 .0018-82e1-aea6 / 0
CIST RegRoot/IRPC   :4096 .0018-82e1-aea6 / 0
CIST RootPortId     :0.0
BPDU-Protection     :disabled
TC or TCN received  :62
TC count per hello  :0
STP Converge Mode   :Nomal
```

```
Time since last TC :0 days 0h:0m:3s
……output omit……

[S2]display stp
-------[CIST Global Info][Mode STP]-------
CIST Bridge         :8192 .0018-82e1-ae82
Bridge Times        :Hello 2s MaxAge 20s FwDly 15s MaxHop 20
CIST Root/ERPC      :4096 .0018-82e1-aea6 / 20000
CIST RegRoot/IRPC   :8192 .0018-82e1-ae82 / 0
CIST RootPortId     :128.9
BPDU-Protection     :disabled
TC or TCN received  :174
TC count per hello  :2
STP Converge Mode   :Nomal
Time since last TC :0 days 0h:0m:1s
……output omit……
```

由以上输出可以看出，S1成为了新的根桥。

关闭S1上G0/0/9、0/0/10、G0/0/13、G0/0/14四个接口达到隔离S1的目的。

```
[S1]interface GigabitEthernet 0/0/9
[S1-GigabitEthernet0/0/9]shutdown
[S1-GigabitEthernet0/0/9]interface GigabitEthernet 0/0/10
[S1-GigabitEthernet0/0/10]shutdown
[S1-GigabitEthernet0/0/10]interface GigabitEthernet 0/0/13
[S1-GigabitEthernet0/0/13]shutdown
[S1-GigabitEthernet0/0/13]interface GigabitEthernet 0/0/14
[S1-GigabitEthernet0/0/14]shutdown

[S2]display stp
-------[CIST Global Info][Mode STP]-------
CIST Bridge         :8192 .0018-82e1-ae82
Bridge Times        :Hello 2s MaxAge 20s FwDly 15s MaxHop 20
CIST Root/ERPC      :8192 .0018-82e1-ae82 / 0
CIST RegRoot/IRPC   :8192 .0018-82e1-ae82 / 0
CIST RootPortId     :0.0
BPDU-Protection     :disabled
TC or TCN received  :197
TC count per hello  :0
STP Converge Mode   :Nomal
Time since last TC :0 days 0h:0m:3s
……output omit……
```

由以上灰色突出显示部分可以看出，在S1失效的情况下，S2由备份根桥成为了根桥。

开启S1之前关闭的接口。

```
[S1]interface GigabitEthernet 0/0/9
[S1-GigabitEthernet0/0/9]undo shutdown
[S1-GigabitEthernet0/0/9]interface GigabitEthernet 0/0/10
[S1-GigabitEthernet0/0/10]undo shutdown
[S1-GigabitEthernet0/0/10]interface GigabitEthernet 0/0/13
[S1-GigabitEthernet0/0/13]undo shutdown
[S1-GigabitEthernet0/0/13]interface GigabitEthernet 0/0/14
[S1-GigabitEthernet0/0/14]undo shutdown

[S1]display stp
-------[CIST Global Info][Mode STP]-------
CIST Bridge         :4096 .0018-82e1-aea6
Bridge Times        :Hello 2s MaxAge 20s FwDly 15s MaxHop 20
CIST Root/ERPC      :4096 .0018-82e1-aea6 / 0
CIST RegRoot/IRPC   :4096 .0018-82e1-aea6 / 0
CIST RootPortId     :0.0
BPDU-Protection     :disabled
TC or TCN received  :63
TC count per hello  :0
STP Converge Mode   :Nomal
Time since last TC :0 days 0h:1m:6s
……output omit……

[S2]display stp
-------[CIST Global Info][Mode STP]-------
CIST Bridge         :8192 .0018-82e1-ae82
Bridge Times        :Hello 2s MaxAge 20s FwDly 15s MaxHop 20
CIST Root/ERPC      :4096 .0018-82e1-aea6 / 20000
CIST RegRoot/IRPC   :8192 .0018-82e1-ae82 / 0
CIST RootPortId     :128.9
BPDU-Protection     :disabled
TC or TCN received  :251
TC count per hello  :0
STP Converge Mode   :Nomal
Time since last TC :0 days 0h:0m:1s
……output omit……
```

由以上输出可以看出，当S1恢复后，S1重新被选举成为根桥。

步骤三. 根端口选举控制

在S2上使用**display stp brief**查看当前接口的角色信息。

```
[S2]display stp brief
 MSTID  Port                        Role  STP State     Protection
   0    GigabitEthernet0/0/9        ROOT  FORWARDING      NONE
   0    GigabitEthernet0/0/10       ALTE  DISCARDING      NONE
   0    GigabitEthernet0/0/23       DESI  FORWARDING      NONE
   0    GigabitEthernet0/0/24       DESI  FORWARDING      NONE
```

此时，G0/0/9为根端口，G0/0/10为替代端口，我们将在下面通过修改S1的端口优先级的方式实现S2的端口G0/0/10成为根端口，G0/0/9成为替代端口。

修改S1接口G0/0/9和G0/0/10的端口优先级。

端口优先级默认值为128，数值越大优先级越小，因此在下面实验中我们将S1的接口G0/0/9端口优先级设置为32，G0/0/10端口优先级设置为16，这样S1的接口G0/0/10优先级高于G0/0/9，S2的接口G0/0/10将选举成为新的根端口。

```
[S1]interface GigabitEthernet 0/0/9
[S1-GigabitEthernet0/0/9]stp port priority 32
[S1-GigabitEthernet0/0/9]interface GigabitEthernet 0/0/10
[S1-GigabitEthernet0/0/10]stp port priority 16
```

提示：此处是修改S1的端口优先级，而不是修改S2的端口优先级。

```
[S1]display stp interface GigabitEthernet 0/0/9
----[CIST][Port9(GigabitEthernet0/0/9)][FORWARDING]----
 Port Protocol      :enabled
 Port Role         :Designated Port
 Port Priority      :32
 Port Cost(Dot1T )   :Config=auto / Active=20000
 Desg. Bridge/Port   :4096.0018-82e1-aea6 / 32.9
 Port Edged         :Config=default / Active=disabled
 Point-to-point      :Config=auto / Active=true
 Transit Limit      :147 packets/hello-time
 Protection Type     :None
 Port Stp Mode      :STP
 Port Protocol Type  :Config=auto / Active=dot1s
 PortTimes         :Hello 2s MaxAge 20s FwDly 15s RemHop 20
 TC or TCN send  :0
 TC or TCN received  :0
 BPDU Sent         :229
        TCN: 0, Config: 229, RST: 0, MST: 0
```

```
 BPDU Received      :3
        TCN: 1, Config: 2, RST: 0, MST: 0

[S1]display stp interface GigabitEthernet 0/0/10
----[CIST][Port10(GigabitEthernet0/0/10)][FORWARDING]----
 Port Protocol      :enabled
 Port Role         :Designated Port
 Port Priority      :16
 Port Cost(Dot1T )   :Config=auto / Active=20000
 Desg. Bridge/Port   :4096.0018-82e1-aea6 / 16.10
 Port Edged         :Config=default / Active=disabled
 Point-to-point      :Config=auto / Active=true
 Transit Limit      :147 packets/hello-time
 Protection Type     :None
 Port Stp Mode      :STP
 Port Protocol Type  :Config=auto / Active=dot1s
 PortTimes          :Hello 2s MaxAge 20s FwDly 15s RemHop 20
 TC or TCN send  :0
 TC or TCN received  :0
 BPDU Sent          :210
        TCN: 0, Config: 210, RST: 0, MST: 0
 BPDU Received      :3
        TCN: 1, Config: 2, RST: 0, MST: 0
```

在S2上使用**display stp brief**查看当前接口的角色信息。

```
[S2]display stp brief
 MSTID  Port                        Role  STP State     Protection
   0    GigabitEthernet0/0/9         ALTE  DISCARDING      NONE
   0    GigabitEthernet0/0/10        ROOT  FORWARDING      NONE
   0    GigabitEthernet0/0/23        DESI  FORWARDING      NONE
   0    GigabitEthernet0/0/24        DESI  FORWARDING      NONE
```

由上输出可以看出，S2的接口G0/0/10被选举成为了新的根端口，G0/0/9成为了替代端口。

关闭S2上的根端口G0/0/10，观察替代端口选举为新的根端口的情况。

```
[S2]interface GigabitEthernet 0/0/10
[S2-GigabitEthernet0/0/10]shutdown
<S2>display stp brief
 MSTID  Port                        Role  STP State     Protection
   0    GigabitEthernet0/0/9         ROOT  FORWARDING      NONE
   0    GigabitEthernet0/0/23        DESI  FORWARDING      NONE
   0    GigabitEthernet0/0/24        DESI  FORWARDING      NONE
```

此时G0/0/9被选举成为了新的根端口。

步骤四. 边缘端口配置

将连接用户终端设备如计算机的端口配置成边缘端口，可以使该端口无需经历STP计算过程快速进入转发状态。本任务中，仅作示例将S3接口E0/0/3-4配置成边缘端口，实际网络中可以根据需要配置。

```
[S3]interface Ethernet0/0/3
[S3-Ethernet0/0/3]stp edged-port enable
[S3-Ethernet0/0/3]interface Ethernet0/0/4
[S3-Ethernet0/0/4]stp edged-port enable
```

配置完成后可以将计算机网线接入到S3的接口E0/0/3，在S3上使用**display stp brief**命令查看端口状态。由于E0/0/2是边缘端口，发现端口立刻就转变到"Forwarding"状态了。

而连接到其它没有配置边缘端口的如E0/0/5接口则在链路**UP**之后要等待约30秒才能达到"Forwarding"状态。

附加实验: 思考并验证

为什么我们需要影响根网桥的选举？我们人工选定网桥的依据通常是什么？

列举出在不同的情况下，一个接口从阻塞状态到转发状态需要经过哪些过程？需要多少时间？

传统STP收敛很慢，如何进行提速？

最终设备配置

```
[S1]display current-configuration
#
!Software Version V100R006C00SPC800
 sysname S1
```

```
#
 vlan batch 1
#
 stp mode stp
 stp instance 0 priority 4096
 stp enable
#
interface GigabitEthernet0/0/9
 stp instance 0 port priority 32
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/10
 stp instance 0 port priority 16
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/13
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/14
 ntdp enable
 ndp enable
 bpdu enable
#
return
```

```
[S2]display current-configuration
#
 !Software Version V100R006C00SPC800
sysname S2
#
 vlan batch 1
#
 stp mode stp
 stp instance 0 priority 8192
 stp enable
#
```

```
interface GigabitEthernet0/0/9
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/10
 shutdown
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/23
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/24
 ntdp enable
 ndp enable
 bpdu enable
#
return
```

```
[S3]display current-configuration
#
!Software Version V100R006C00SPC800
sysname S3
#
 stp mode stp
 stp enable
#
interface Ethernet0/0/1
 shutdown
 bpdu enable
#     interface Ethernet0/0/3
 stp edged-port enable
 bpdu enable
#
interface Ethernet0/0/4
 stp edged-port enable
 bpdu enable
#
```

```
interface Ethernet0/0/13
 bpdu enable
#
interface Ethernet0/0/23
 bpdu enable
#
return

[S4]display current-configuration
#
!Software Version V100R006C00SPC800
 sysname S4
#
 stp mode stp
 stp enable
#
interface Ethernet0/0/1
 bpdu enable
#
interface Ethernet0/0/14
 bpdu enable
#
interface Ethernet0/0/24
 bpdu enable
#
return
```

实验 6-3 VLAN 配置

学习目的

- 了解VLAN的意义
- 理解VLAN的安全性表现
- 掌握VLAN的配置
- 掌握Access接口与Trunk接口的配置
- 掌握将接口与VLAN关联的配置
- 掌握Hybrid接口的配置

拓扑图

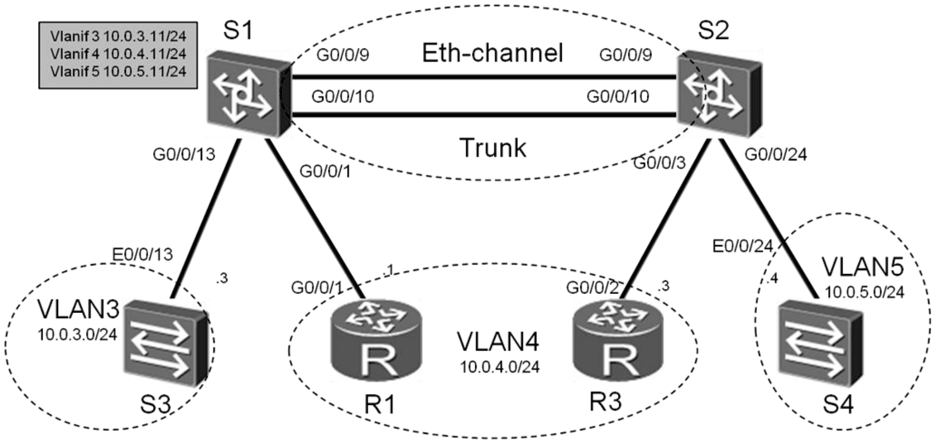


图6.3 VLAN配置拓扑图

场景

你是你们公司的网络管理员。当前网络中需要部署VLAN。购置了两台交换机。你需要部署VLAN和其他特性。

学习任务

步骤一. Eth-trunk 链路聚合

实验之前，需要关闭部分设备接口，避免影响本次实验。

本次实验需要关闭S3的Ethernet0/0/1、Ethernet0/0/23接口，另外需要关闭S4的Ethernet0/0/14接口。

S1与S2之间的两条链路，如果开启STP，则会有一条链路被禁用，造成带宽的浪费；如果不使用STP，则会造成环路。但是如果使用Eth-trunk，则可以很好的解决这个问题。

配置Eth-trunk之前，必须清除接口原有配置信息。

配置Eth-trunk时，可以将物理接口加入Eth-trunk组，也可以在Eth-trunk配置模式下，添加物理接口。

S1使用第一种模式配置Eth-trunk与物理接口之间的关联关系。

```
<Quidway>system-view
[Quidway]sysname S1
[S1]interface eth-trunk 1
[S1-Eth-Trunk1]quit
[S1]interface gigabitethernet0/0/9
[S1-GigabitEthernet0/0/9]eth-trunk 1
[S1-GigabitEthernet0/0/9]interface gigabitethernet0/0/10
[S1-GigabitEthernet0/0/10]eth-trunk 1
```

S2使用第二种模式配置Eth-trunk与物理接口之间的关联关系。

```
<Quidway>system-view
[Quidway]sysname S2
[S2]interface eth-trunk 1
[S2-Eth-Trunk1]trunkport GigabitEthernet 0/0/9
[S2-Eth-Trunk1]trunkport GigabitEthernet 0/0/10
```

接口默认的链路类型为Hybird类型，可以直接修改链路类型为Trunk类型。

另外需要注意的时，默认情况下，接口的Trunk功能禁止所有VLAN的数据传输过去。

```
[S1]interface Eth-Trunk 1
[S1-Eth-Trunk1]port link-type trunk
[S1-Eth-Trunk1]port trunk allow-pass vlan all
```

```
[S2]interface Eth-Trunk 1
[S2-Eth-Trunk1]port link-type trunk
[S2-Eth-Trunk1]port trunk allow-pass vlan all
```

步骤二. 配置 VLAN

实验中S3、R1、R3、S4模拟为主机进行测试。其中S3属于VLAN3、R1、R3属于VLAN4、S4属于VLAN5。

配置号码连续的多个VLAN的方式有两种。实验中分别演示。

定义VLAN与接口的对应关系也有两种方式，实验中分别演示。

```
[S1]interface GigabitEthernet0/0/13
[S1-GigabitEthernet0/0/13]port link-type access
[S1-GigabitEthernet0/0/13]interface GigabitEthernet0/0/1
[S1-GigabitEthernet0/0/1]port link-type access
[S1-GigabitEthernet0/0/1]vlan 3
[S1-vlan3]port GigabitEthernet0/0/13
[S1-vlan3]vlan 4
[S1-vlan4]port GigabitEthernet0/0/1
[S1-vlan4]vlan 5

[S2]vlan batch 3 to 5
[S2]interface GigabitEthernet 0/0/3
[S2-GigabitEthernet0/0/3]port link-type access
[S2-GigabitEthernet0/0/3]port default vlan 4
[S2-GigabitEthernet0/0/3]interface GigabitEthernet 0/0/24
[S2-GigabitEthernet0/0/24]port link-type access
[S2-GigabitEthernet0/0/24]port default vlan 5
```

步骤三. 规划地址

R1、R3、S3和S4模拟为客户端，测试VLAN配置效果。

需要各自配置接口地址，其中交换机物理接口无法配置地址，在VLANIF1接口配置IP地址。

```
<Quidway>system-view
[Quidway]sysname S3
[S3]interface vlanif 1
[S3-vlanif1]ip address 10.0.3.3 24
```

```
<Huawei>system-view
[Huawei]sysname R1
[R1]interface GigabitEthernet0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.4.1 24

<Huawei>system-view
[Huawei]sysname R3
[R3]interface GigabitEthernet0/0/2
[R3-GigabitEthernet0/0/2]ip address 10.0.4.3 24

<Quidway>system-view
[Quidway]sysname S4
[S4]interface vlanif 1
[S4-vlanif1]ip address 10.0.5.4 24
```

步骤四. 测试

使用**ping**命令，正常情况下，同属于vlan4的R1与R3之间可以通讯，其余两两相互不能通讯。

```
[R3]ping 10.0.4.1
  PING 10.0.4.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.4.1: bytes=56 Sequence=1 ttl=255 time=6 ms
    Reply from 10.0.4.1: bytes=56 Sequence=2 ttl=255 time=2 ms
    Reply from 10.0.4.1: bytes=56 Sequence=3 ttl=255 time=2 ms
    Reply from 10.0.4.1: bytes=56 Sequence=4 ttl=255 time=2 ms
    Reply from 10.0.4.1: bytes=56 Sequence=5 ttl=255 time=2 ms

  --- 10.0.4.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 2/2/6 ms
```

其余设备之间则无法相互通讯，可以测试R1与S3之间、R3与S4之间通讯情况。

在S1上为每个VLAN配置一个管理地址。相当于在S1上连接了三台客户端，属于VLAN3、4、5。

```
[S1]interface Vlanif 3
[S1-Vlanif3]ip address 10.0.3.11 24
```

```
[S1-Vlanif3]interface Vlanif 4
[S1-Vlanif4]ip address 10.0.4.11 24
[S1-Vlanif4]interface Vlanif 5
[S1-Vlanif5]ip address 10.0.5.11 24
```

配置完成后，可以在S1上测试所有VLAN内部客户端是否正常通讯。

```
 [S1]ping 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=255 time=10 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=255 time=10 ms

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/4/10 ms

[S1]ping 10.0.4.1
  PING 10.0.4.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.4.1: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.4.1: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.4.1: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.4.1: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.4.1: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.4.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[S1]ping 10.0.4.3
  PING 10.0.4.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.4.3: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.4.3: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.4.3: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.4.3: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.4.3: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.4.3 ping statistics ---
```

```
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[S1]ping 10.0.5.4
  PING 10.0.5.4: 56  data bytes, press CTRL_C to break
    Reply from 10.0.5.4: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.5.4: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.5.4: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.5.4: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.5.4: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.5.4 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

步骤五. 掌握 Hybrid 接口的配置

Hybird接口与Trunk接口类似，但是增加了一些功能，可以实现在不同VLAN的用户通讯，比如实验中S3与R3设备。当前他们首先需要在同一个网段。

修改S3与R3地址。

```
[S3]interface Vlanif 1
[S3-Vlanif1]ip address 10.0.6.3 24

[R3]interface GigabitEthernet 0/0/2
[R3-GigabitEthernet0/0/2]ip address 10.0.6.4 24
```

定义S1的G0/0/13接口为Hybird接口，属于VLAN3。对VLAN3和VLAN4定义为Untagged。注意修改链路类型之前，需要删除接口的额外配置。

```
[S1]interface GigabitEthernet0/0/13
[S1-GigabitEthernet0/0/13]undo port default vlan
[S1-GigabitEthernet0/0/13]port link-type hybrid
[S1-GigabitEthernet0/0/13]port hybrid pvid vlan 3
[S1-GigabitEthernet0/0/13]port hybrid untagged vlan 3 to 4
```

定义S2的G0/0/3接口为Hybird接口，属于VLAN4。对VLAN3和VLAN4定义为Untagged。

```
[S2]interface GigabitEthernet0/0/3
[S2-GigabitEthernet0/0/3]undo port default vlan
[S2-GigabitEthernet0/0/3]port link-type hybrid
[S2-GigabitEthernet0/0/3]port hybrid pvid vlan 4
[S2-GigabitEthernet0/0/3]port hybrid untagged vlan 3 to 4
```

此时S3与R3虽然在不同网段，但是可以实现互通。

```
[S3]ping 10.0.6.4
  PING 10.0.6.4: 56  data bytes, press CTRL_C to break
    Reply from 10.0.6.4: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.6.4: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.6.4: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.6.4: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.6.4: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.6.4 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

附加实验：思考并验证

思考接口的Hybird模式适合使用在什么场景下？

最终设备配置

```
[S1]display current-configuration
#
 !Software Version V100R006C00SPC800
sysname S1
#
 vlan batch 1 3 to 5
#
interface Vlanif1
#
interface Vlanif3
 ip address 10.0.3.11 255.255.255.0
#
```

```
interface Vlanif4
 ip address 10.0.4.11 255.255.255.0
#
interface Vlanif5
 ip address 10.0.5.11 255.255.255.0
#
interface MEth0/0/1
#
interface Eth-Trunk1
 port link-type trunk
 port trunk allow-pass vlan 2 to 4094
 bpdu enable
#
interface GigabitEthernet0/0/1
 port link-type access
 port default vlan 4
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/9
 eth-trunk 1
 undo ntdp enable
 undo ndp enable
#
interface GigabitEthernet0/0/10
 eth-trunk 1
 undo ntdp enable
 undo ndp enable
#
interface GigabitEthernet0/0/13
 port hybrid pvid vlan 3
 port hybrid untagged vlan 3 to 4
 ntdp enable
 ndp enable
 bpdu enable
#
interface NULL0
#
return

[S2]display current-configuration
#
```

```
 !Software Version V100R006C00SPC800
sysname S2
#
 vlan batch 1 3 to 5
#
interface Vlanif1
#
interface MEth0/0/1
#
interface Eth-Trunk1
 port link-type trunk
 port trunk allow-pass vlan 2 to 4094
 bpdu enable
#
interface GigabitEthernet0/0/3
 port hybrid pvid vlan 4
 port hybrid untagged vlan 3 to 4
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/9
 eth-trunk 1
 undo ntdp enable
 undo ndp enable
#
interface GigabitEthernet0/0/10
 eth-trunk 1
 undo ntdp enable
 undo ndp enable
#
interface GigabitEthernet0/0/24
 port link-type access
 port default vlan 5
 ntdp enable
 ndp enable
 bpdu enable
#
return

[S3]display current-configuration
#
!Software Version V100R006C00SPC800
```

```
 sysname S3
#
interface Vlanif1
 ip address 10.0.6.3 255.255.255.0
#
interface Ethernet0/0/13
 bpdu enable
#
return

[S4]display current-configuration
#
!Software Version V100R006C00SPC800
 sysname S4
#
interface Vlanif1
 ip address 10.0.5.4 255.255.255.0
#
interface Ethernet0/0/24
 bpdu enable
#
return

[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
interface GigabitEthernet0/0/1
 ip address 10.0.4.1 255.255.255.0
#
return

[R3]display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
interface GigabitEthernet0/0/2
 ip address 10.0.6.4 255.255.255.0
#
return
```

第七章 三层交换与虚拟路由器冗余协议

实验 7-1 三层交换

学习目的

- 了解三层交换的意义
- 理解三层交换与路由的异同点
- 掌握VLANIF的配置方法
- 掌握VLAN之间实现通讯的配置方法
- 掌握VLANIF之间配置OSPF的方法

拓扑图

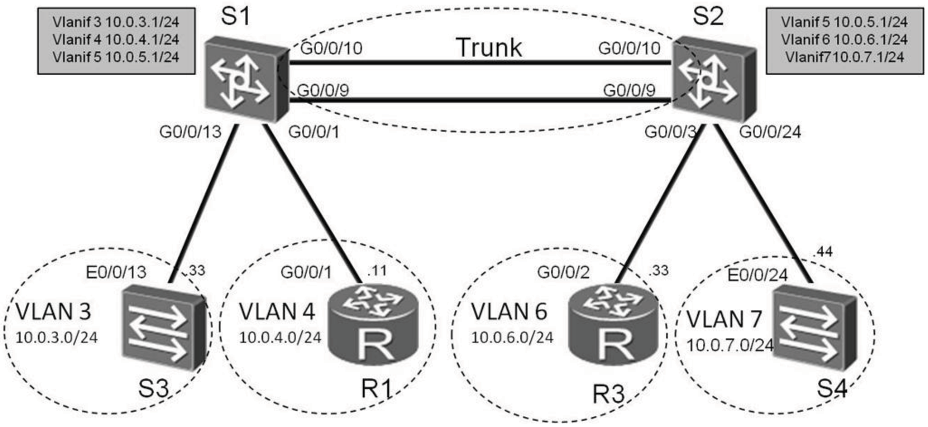


图7.1 三层交换实验拓扑图

场景

你是你们公司的网络管理员。当前的网络中有四个用户，用S3、R1、R3与S4模拟为公司用户。分属于不同的VLAN，定义S3属于VLAN3、R1属于Vlan4、R3属于VLAN6、S4属于VLAN7，实现VLAN之间的互通。同时由于S1与S2之间

使用三层链路实现互通，所以需要使用路由协议实现路由信息的相互学习。

学习任务

步骤一.　S1 与 S2 之间的链路配置成 Eth-Trunk 链路

实验之前，需要关闭部分设备接口，避免影响本次实验。

本次实验需要关闭S3的Ethernet0/0/1、Ethernet0/0/23接口，另外需要关闭S4的Ethernet0/0/14接口。关闭这些接口之后，开始实验配置。

```
<Quidway>system-view
[Quidway]sysname S1
[S1]interface Eth-Trunk 1
[S1-Eth-Trunk1]quit
[S1]interface GigabitEthernet 0/0/9
[S1-GigabitEthernet0/0/9]eth-trunk 1
[S1-GigabitEthernet0/0/9]interface GigabitEthernet 0/0/10
[S1-GigabitEthernet0/0/10]eth-trunk 1

<Quidway>system-view
[Quidway]sysname S2
[S2]interface Eth-Trunk 1
[S2-Eth-Trunk1]quit
[S2]interface GigabitEthernet 0/0/9
[S2-GigabitEthernet0/0/9]eth-trunk 1
[S2-GigabitEthernet0/0/9]interface GigabitEthernet 0/0/10
[S2-GigabitEthernet0/0/10]eth-trunk 1
```

步骤二.　S1、S2 配置 VLAN 3、4、5、6、7

```
[S1]vlan batch 3 to 7

[S2]vlan batch 3 to 7
```

查看VLAN的创建情况

```
[S1]display vlan
The total number of vlans is : 6
--------------------------------------------------------------------------
U: Up;         D: Down;         TG: Tagged;         UT: Untagged;
MP: Vlan-mapping;               ST: Vlan-stacking;
```

```
#: ProtocolTransparent-vlan;    *: Management-vlan;
--------------------------------------------------------------------------------

VID  Type    Ports
--------------------------------------------------------------------------------
1    common  UT:GE0/0/1(U)     GE0/0/2(U)     GE0/0/3(U)     GE0/0/4(D)
                GE0/0/5(D)      GE0/0/6(D)      GE0/0/7(D)      GE0/0/8(D)
                GE0/0/9(U)      GE0/0/10(U)     GE0/0/11(D)     GE0/0/12(D)
                GE0/0/13(U)     GE0/0/14(U)     GE0/0/15(D)     GE0/0/16(D)
                GE0/0/17(D)     GE0/0/18(D)     GE0/0/19(D)     GE0/0/20(D)
                GE0/0/21(U)     GE0/0/22(U)     GE0/0/23(U)     GE0/0/24(D)
3    common
4    common
5    common
6    common
7    common

VID  Status  Property     MAC-LRN Statistics Description
--------------------------------------------------------------------------------
1    enable  default      enable  disable    VLAN 0001
3    enable  default      enable  disable    VLAN 0003
4    enable  default      enable  disable    VLAN 0004
5    enable  default      enable  disable    VLAN 0005
6    enable  default      enable  disable    VLAN 0006
7    enable  default      enable  disable    VLAN 0007

[S2]display vlan
The total number of vlans is : 6
--------------------------------------------------------------------------------
U: Up;         D: Down;         TG: Tagged;         UT: Untagged;
MP: Vlan-mapping;               ST: Vlan-stacking;
#: ProtocolTransparent-vlan;    *: Management-vlan;
--------------------------------------------------------------------------------

VID  Type    Ports
--------------------------------------------------------------------------------
1    common  UT:GE0/0/1(U)     GE0/0/2(U)     GE0/0/3(U)     GE0/0/4(D)
                GE0/0/5(D)      GE0/0/6(D)      GE0/0/7(D)      GE0/0/8(D)
                GE0/0/9(U)      GE0/0/10(U)     GE0/0/11(D)     GE0/0/12(D)
                GE0/0/13(D)     GE0/0/14(D)     GE0/0/15(D)     GE0/0/16(D)
                GE0/0/17(D)     GE0/0/18(D)     GE0/0/19(D)     GE0/0/20(D)
                GE0/0/21(D)     GE0/0/22(D)     GE0/0/23(U)     GE0/0/24(U)
3    common
```

```
4    common
5    common
6    common
7    common

VID  Status  Property     MAC-LRN Statistics Description
----------------------------------------------------------------------------
1    enable  default      enable  disable    VLAN 0001
3    enable  default      enable  disable    VLAN 0003
4    enable  default      enable  disable    VLAN 0004
5    enable  default      enable  disable    VLAN 0005
6    enable  default      enable  disable    VLAN 0006
7    enable  default      enable  disable    VLAN 0007
```

步骤三. S1 与 S2 之间的 Eth-Trunk 链路配置为 Access 链路，属于 VLAN5

配置VLAN与接口之间的对应关系。S1与S2之间的Eth-Trunk属于VLAN5，S1的G0/0/1属于VLAN4、G0/0/13属于VLAN3；S2的G0/0/3属于VLAN6、G0/0/24属于VLAN7。

```
[S1]interface Eth-Trunk 1
[S1-Eth-Trunk1]port link-type access
[S1-Eth-Trunk1]port default vlan 5
[S1-Eth-Trunk1]interface GigabitEthernet 0/0/1
[S1-GigabitEthernet0/0/1]port link-type access
[S1-GigabitEthernet0/0/1]port default vlan 4
[S1-GigabitEthernet0/0/1]interface GigabitEthernet 0/0/13
[S1-GigabitEthernet0/0/13]port link-type access
[S1-GigabitEthernet0/0/13]port default vlan 3

[S2]interface Eth-Trunk 1
[S2-Eth-Trunk1]port link-type access
[S2-Eth-Trunk1]port default vlan 5
[S2-Eth-Trunk1]interface GigabitEthernet 0/0/3
[S2-GigabitEthernet0/0/3]port link-type access
[S2-GigabitEthernet0/0/3]port default vlan 6
[S2-GigabitEthernet0/0/3]interface GigabitEthernet 0/0/24
[S2-GigabitEthernet0/0/24]port link-type access
[S2-GigabitEthernet0/0/24]port default vlan 7
```

步骤四.　S1 与 S2 为相应的 VLAN 配置网关 IP 地址

S1为VLAN3、4、5提供网关服务，S2为VLAN5、6、7提供网关服务。

```
[S1]interface Vlanif 3
[S1-Vlanif3]ip address 10.0.3.1 24
[S1-Vlanif3]interface Vlanif 4
[S1-Vlanif4]ip address 10.0.4.1 24
[S1-Vlanif4]interface Vlanif 5
[S1-Vlanif5]ip address 10.0.5.1 24

[S2]interface Vlanif 5
[S2-Vlanif5]ip address 10.0.5.2 24
[S2-Vlanif5]interface Vlanif 6
[S2-Vlanif6]ip address 10.0.6.1 24
[S2-Vlanif6]interface Vlanif 7
[S2-Vlanif7]ip address 10.0.7.1 24
```

步骤五.　S3、R1、R3、S4 配置相应的 IP 地址，并配置缺省路由

```
<Quidway>system-view
[Quidway]sysname S3
[S3]interface Vlanif 1
[S3-Vlanif1]ip address 10.0.3.33 24
[S3-Vlanif1]quit
[S3]ip route-static 0.0.0.0 0 10.0.3.1
```

注：由于交换机的物理接口无法配置IP地址，所有我们只能通过Vlanif接口实现。虽然S3逻辑上属于S1上定义的VLAN3，但是S3的E0/0/13接口在S3上属于VLAN1，所以在S3上我们给Vlanif1配置IP地址，才能将S3模拟成一台连接到S1的主机，并属于VLAN3。S4交换机的配置思路与这里一样。

```
<Huawei>system-view
[Huawei]sysname R1
[R1]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.4.11 24
[R1-GigabitEthernet0/0/1]quit
[R1]ip route-static 0.0.0.0 0 10.0.4.1

<Huawei>system-view
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/2
```

```
[R3-GigabitEthernet0/0/2]ip address 10.0.6.33 24
[R3-GigabitEthernet0/0/2]quit
[R3]ip route-static 0.0.0.0 0 10.0.6.1

<Quidway>system-view
[Quidway]sysname S4
[S4]interface Vlanif 1
[S4-Vlanif1]ip address 10.0.7.44 24
[S4-Vlanif1]quit
[S4]ip route-static 0.0.0.0 0 10.0.7.1
```

步骤六. 测试 VLAN3 与 VLAN4 之间的连通性

在R1上测试与S3的连通性。

```
[R1]ping 10.0.3.33
  PING 10.0.3.33: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.33: bytes=56 Sequence=1 ttl=254 time=16 ms
    Reply from 10.0.3.33: bytes=56 Sequence=2 ttl=254 time=5 ms
    Reply from 10.0.3.33: bytes=56 Sequence=3 ttl=254 time=4 ms
    Reply from 10.0.3.33: bytes=56 Sequence=4 ttl=254 time=4 ms
    Reply from 10.0.3.33: bytes=56 Sequence=5 ttl=254 time=4 ms

  --- 10.0.3.33 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 4/6/16 ms
```

在R1上测试与R3的连通性，如下

```
[R1]ping 10.0.6.33
  PING 10.0.6.33: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.6.33 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss
```

R1与R3之间不能通信。可依照以下检查思路进行故障排除。

```
[R1]tracert 10.0.6.33
 traceroute to  10.0.6.33(10.0.6.33), max hops: 30 ,packet length: 40,press CTRL_C
to break
 1 10.0.4.1 62 ms  4 ms  4 ms
 2  *  *  *
```

如上显示，R1已经把目标地址为10.0.6.33的数据报发送出去了。但是10.0.4.1（即网关）回应网络不可达。

所以我们可以到网关（S1）上查看是否因为路由原因而不可达。

```
[S1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
       Destinations : 8       Routes : 8

Destination/Mask    Proto  Pre  Cost      Flags NextHop        Interface

      10.0.3.0/24  Direct 0    0           D   10.0.3.1       Vlanif3
      10.0.3.1/32  Direct 0    0           D   127.0.0.1      InLoopBack0
      10.0.4.0/24  Direct 0    0           D   10.0.4.1       Vlanif4
      10.0.4.1/32  Direct 0    0           D   127.0.0.1      InLoopBack0
      10.0.5.0/24  Direct 0    0           D   10.0.5.1       Vlanif5
      10.0.5.1/32  Direct 0    0           D   127.0.0.1      InLoopBack0
     127.0.0.0/8   Direct 0    0           D   127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct 0    0           D   127.0.0.1      InLoopBack0
```

这里可以看到S1缺少到达10.0.6.0网段路由。

原因是这个网段与S1没有直连，未配置静态路由或动态路由协议。

步骤七.　S1 与 S2 之前启用路由协议 OSPF

```
[S1]ospf 1
[S1-ospf-1]area 0
[S1-ospf-1-area-0.0.0.0]network 10.0.0.0 0.255.255.255


[S2]ospf 1
[S2-ospf-1]area 0
[S2-ospf-1-area-0.0.0.0]network 10.0.0.0 0.255.255.255
```

配置完成后，稍等片刻，待S1与S2的OSPF协议相互交换路由信息后。查看S1的路由表。

```
[S1]display ip routing-table
Route Flags: R - relay, D - download to fib
----------------------------------------------------------------------------
Routing Tables: Public
       Destinations : 10      Routes : 10

Destination/Mask    Proto  Pre  Cost      Flags NextHop         Interface

      10.0.3.0/24  Direct 0    0           D   10.0.3.1        Vlanif3
      10.0.3.1/32  Direct 0    0           D   127.0.0.1        InLoopBack0
      10.0.4.0/24  Direct 0    0           D   10.0.4.1        Vlanif4
      10.0.4.1/32  Direct 0    0           D   127.0.0.1        InLoopBack0
      10.0.5.0/24  Direct 0    0           D   10.0.5.1        Vlanif5
      10.0.5.1/32  Direct 0    0           D   127.0.0.1        InLoopBack0
      10.0.6.0/24  OSPF   10   2           D   10.0.5.2        Vlanif5
      10.0.7.0/24  OSPF   10   2           D   10.0.5.2        Vlanif5
     127.0.0.0/8   Direct 0    0           D   127.0.0.1        InLoopBack0
     127.0.0.1/32  Direct 0    0           D   127.0.0.1        InLoopBack0
```

此时S1通过OSPF协议学到了两条路由信息。

测试R1与R3之间的连通性。

```
[R1]ping 10.0.6.33
  PING 10.0.6.33: 56  data bytes, press CTRL_C to break
    Reply from 10.0.6.33: bytes=56 Sequence=1 ttl=253 time=8 ms
    Reply from 10.0.6.33: bytes=56 Sequence=2 ttl=253 time=2 ms
    Reply from 10.0.6.33: bytes=56 Sequence=3 ttl=253 time=2 ms
    Reply from 10.0.6.33: bytes=56 Sequence=4 ttl=253 time=2 ms
    Reply from 10.0.6.33: bytes=56 Sequence=5 ttl=253 time=2 ms

  --- 10.0.6.33 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 2/3/8 ms

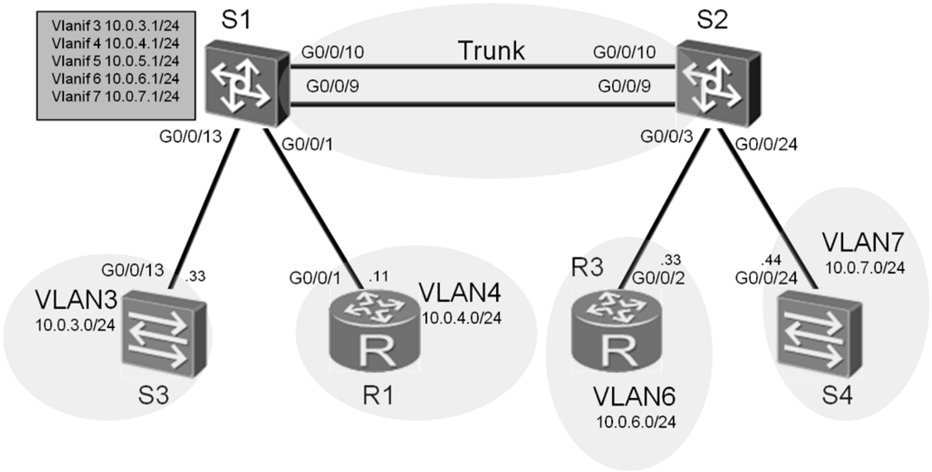
[R1]ping 10.0.7.44
  PING 10.0.7.44: 56  data bytes, press CTRL_C to break
    Reply from 10.0.7.44: bytes=56 Sequence=1 ttl=252 time=12 ms
```

```
  Reply from 10.0.7.44: bytes=56 Sequence=2 ttl=253 time=4 ms
  Reply from 10.0.7.44: bytes=56 Sequence=3 ttl=253 time=4 ms
  Reply from 10.0.7.44: bytes=56 Sequence=4 ttl=253 time=4 ms
  Reply from 10.0.7.44: bytes=56 Sequence=5 ttl=253 time=4 ms

 --- 10.0.7.44 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 4/5/12 ms
```

附加实验：思考并验证

如果S1与S2之间定义为Trunk链路，这样是否可以不使用路由协议也可以实现不同VLAN之间的互通？如下图实现互通。



最终设备配置

```
[S1]display current-configuration
#
 !Software Version V100R006C00SPC800
sysname S1
#
 vlan batch 1 3 to 7
```

```
#
interface Vlanif1
#
interface Vlanif3
 ip address 10.0.3.1 255.255.255.0
#
interface Vlanif4
 ip address 10.0.4.1 255.255.255.0
#
interface Vlanif5
 ip address 10.0.5.1 255.255.255.0
#
interface MEth0/0/1
#
interface Eth-Trunk1
 port link-type access
 port default vlan 5
#
interface GigabitEthernet0/0/1
 port link-type access
 port default vlan 4
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/9
 eth-trunk 1
 undo ntdp enable
 undo ndp enable
#
interface GigabitEthernet0/0/10
 eth-trunk 1
 undo ntdp enable
 undo ndp enable
#
interface GigabitEthernet0/0/13
 port link-type access
 port default vlan 3
 ntdp enable
 ndp enable
 bpdu enable
#
ospf 1
```

```
 area 0.0.0.0
  network 10.0.0.0 0.255.255.255
#
return


[S2]display current-configuration
#
 !Software Version V100R006C00SPC800
sysname S2
#
 vlan batch 1 3 to 7
#
interface Vlanif1
#
interface Vlanif5
 ip address 10.0.5.2 255.255.255.0
#
interface Vlanif6
 ip address 10.0.6.1 255.255.255.0
#
interface Vlanif7
 ip address 10.0.7.1 255.255.255.0
#
interface MEth0/0/1
#
interface Eth-Trunk1
 port link-type access
 port default vlan 5
#
interface GigabitEthernet0/0/3
 port link-type access
 port default vlan 6
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/9
 eth-trunk 1
 undo ntdp enable
 undo ndp enable
#
interface GigabitEthernet0/0/10
```

```
 eth-trunk 1
 undo ntdp enable
 undo ndp enable
#
interface GigabitEthernet0/0/24
 port link-type access
 port default vlan 7
 ntdp enable
 ndp enable
 bpdu enable
#
ospf 1
 area 0.0.0.0
  network 10.0.0.0 0.255.255.255
#
return

[S3]display current-configuration
#
!Software Version V100R006C00SPC800
 sysname S3
#
interface Vlanif1
 ip address 10.0.3.33 255.255.255.0
#
interface Ethernet0/0/13
 bpdu enable
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.3.1
#
return


[S4]display current-configuration
#
!Software Version V100R006C00SPC800
 sysname S4
#
interface Vlanif1
 ip address 10.0.7.44 255.255.255.0
#
interface Ethernet0/0/24
 bpdu enable
```

```
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.7.1
#
return


[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
interface GigabitEthernet0/0/1
 ip address 10.0.4.11 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.4.1
#
return


[R3]display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
interface GigabitEthernet0/0/2
 ip address 10.0.6.33 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.6.1
#
return
```

实验 7-2 VRRP 配置

学习目的

- 了解网络负载均衡的功能和作用
- 理解VRRP协议的工作原理
- 掌握三层交换环境单组VRRP的配置方法
- 掌握VRRP认证配置方法
- 掌握VRRP跟踪接口的配置方法
- 掌握使用VRRP实现负载均衡的配置方法

拓扑图

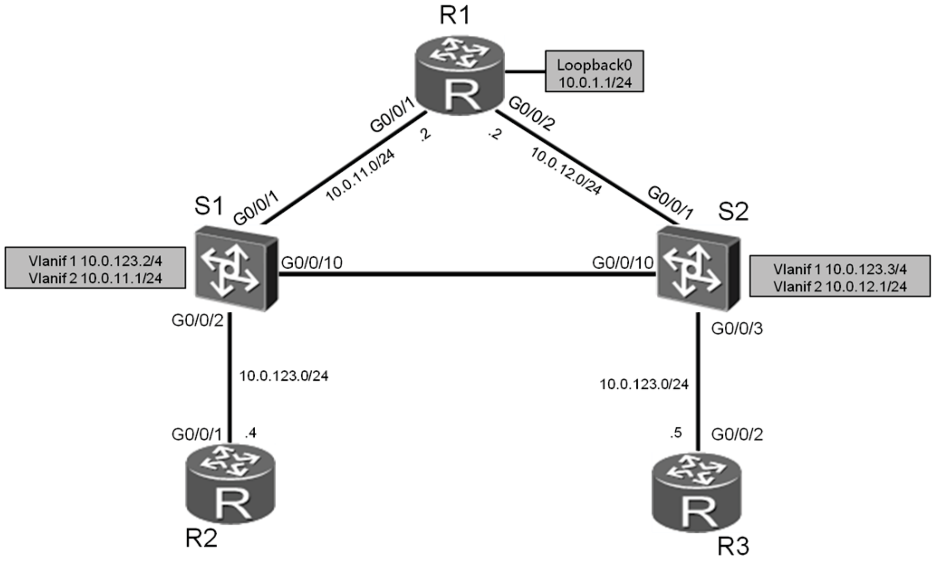


图4.5 VRRP配置实验拓扑图

场景

你是你们公司的网络管理员。当前的网络中有两个用户。用R2、R3模拟为

公司用户。R1使用环回口模拟为Internet服务器。此时网络中有两个网关，为实现冗余，你选择使用VRRP协议来实现冗余。

学习任务

步骤一. 基本配置与 IP 编址

实验之前，需要关闭部分设备接口，避免影响本次实验。

本次实验需要关闭S1的GigabitEthernet0/0/9、GigabitEthernet0/0/13和GigabitEthernet0/0/14接口。关闭这些接口之后，开始实验配置。

用户网络使用VLAN1,S1使用VLAN2与R1相连，S2使用VLAN3与R1相连，R1配置Loopback接口；R2、R3作为客户，配置IP、缺省网关。

路由器R1模拟为广域网，它的环回口模拟为广域网中的一台服务器。

```
[Huawei]sysname R1
[R1]interface LoopBack 0
[R1-LoopBack0]ip address 10.0.1.1 24
[R1-LoopBack0]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.11.2 24
[R1-GigabitEthernet0/0/1]interface GigabitEthernet 0/0/2
[R1-GigabitEthernet0/0/2]ip address 10.0.12.2 24
```

路由器R2模拟为局域网中的一台PC设备，使用网段为10.0.123.0/24，网关为10.0.123.1。

路由器R3模拟为局域网中的另一台PC设备，使用网段为10.0.123.0/24，网关为10.0.123.1。

```
<Huawei>system-view
[Huawei]sysname R2
[R2]interface GigabitEthernet 0/0/1
[R2-GigabitEthernet0/0/1]ip address 10.0.123.4 24
[R2-GigabitEthernet0/0/1]quit
[R2]ip route-static 0.0.0.0 0 10.0.123.1

<Huawei>system-view
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/2
[R3-GigabitEthernet0/0/2]ip address 10.0.123.5 24
[R3-GigabitEthernet0/0/2]quit
[R3]ip route-static 0.0.0.0 0 10.0.123.1
```

交换机S1配置VLAN1、2、3，接口默认为hybird模式。将接口G0/0/10配置为Trunk接口，允许所有VLAN通过，G0/0/1配置为access类型接口，属于VLAN2，G0/0/2配置为access类型接口，属于VLAN1。配置VLANIF 1，为VLAN1提供网关服务，IP地址为10.0.123.2/24；配置VLANIF2，作为与R1连接的三层接口，IP地址为10.0.11.1/24。

```
<Huawei>system-view
[Huawei]sysname S1
[S1]vlan batch 1 to 3
[S1]interface GigabitEthernet 0/0/10
[S1-GigabitEthernet0/0/10]port link-type trunk
[S1-GigabitEthernet0/0/10]port trunk allow-pass vlan all
[S1-GigabitEthernet0/0/10]interface GigabitEthernet 0/0/1
[S1-GigabitEthernet0/0/1]port link-type access
[S1-GigabitEthernet0/0/1]port default vlan 2
[S1-GigabitEthernet0/0/1]interface GigabitEthernet 0/0/2
[S1-GigabitEthernet0/0/2]port link-type access
[S1-GigabitEthernet0/0/2]port default vlan 1
[S1-GigabitEthernet0/0/2]interface Vlanif 1
[S1-Vlanif1]ip address 10.0.123.2 24
[S1-Vlanif1]interface vlanif 2
[S1-Vlanif2]ip address 10.0.11.1 24
```

交换机S2配置VLAN1、2、3，接口默认为hybird模式。将接口G0/0/10配置为Trunk接口，允许所有VLAN通过，G0/0/1配置为access类型接口，属于VLAN3，G0/0/3配置为access类型接口，属于VLAN1。配置VLANIF 1，为VLAN1提供网关服务，IP地址为10.0.123.3/24，配置VLANIF3，作为与R1连接的三层接口，IP地址为10.0.12.1/24。

```
<Huawei>system-view
[Huawei]sysname S2
[S2]vlan batch 1 to 3
[S2]interface GigabitEthernet 0/0/10
[S2-GigabitEthernet0/0/10]port link-type trunk
[S2-GigabitEthernet0/0/10]port trunk allow-pass vlan all
[S2-GigabitEthernet0/0/10]interface GigabitEthernet 0/0/1
[S2-GigabitEthernet0/0/1]port link-type access
[S2-GigabitEthernet0/0/1]port default vlan 3
[S2-GigabitEthernet0/0/1]interface GigabitEthernet 0/0/3
[S2-GigabitEthernet0/0/3]port link-type access
[S2-GigabitEthernet0/0/3]port default vlan 1
[S2-GigabitEthernet0/0/3]interface Vlanif 1
[S2-Vlanif1]ip address 10.0.123.3 24
[S2-Vlanif1]interface Vlanif 3
```

```
[S2-Vlanif3]ip address 10.0.12.1 24
```

配置完成后，测试直连链路的连通性。在S2上测试其于S1、R1、R2、R3之间的连通性。（使用**ping**命令测试时，加上参数“**-c 1**”代表仅发一个**ping**包进行测试。默认连续发送5个。）

```
[S2]ping -c 1 10.0.12.2
  PING 10.0.12.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.12.2: bytes=56 Sequence=1 ttl=255 time=10 ms

  --- 10.0.12.2 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 10/10/10 ms

[S2]ping -c 1 10.0.123.2
  PING 10.0.123.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.123.2: bytes=56 Sequence=1 ttl=255 time=1 ms

  --- 10.0.123.2 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[S2]ping -c 1 10.0.123.4
  PING 10.0.123.4: 56  data bytes, press CTRL_C to break
    Reply from 10.0.123.4: bytes=56 Sequence=1 ttl=255 time=1 ms

  --- 10.0.123.4 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[S2]ping -c 1 10.0.123.5
  PING 10.0.123.5: 56  data bytes, press CTRL_C to break
    Reply from 10.0.123.5: bytes=56 Sequence=1 ttl=255 time=1 ms

  --- 10.0.123.5 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
```

```
    round-trip min/avg/max = 1/1/1 ms
```

步骤二. 配置 OSPF 路由协议，实现 S1、S2、R1 之间的路由连通

```
[S1]ospf 1
[S1-ospf-1]area 0
[S1-ospf-1-area-0.0.0.0]network 10.0.0.0 0.255.255.255
[S1-ospf-1-area-0.0.0.0]quit
[S1-ospf-1]silent-interface Vlanif 1

[S2]ospf 1
[S2-ospf-1]area 0
[S2-ospf-1-area-0.0.0.0]network 10.0.0.0 0.255.255.255
[S2-ospf-1-area-0.0.0.0]quit
[S2-ospf-1]silent-interface Vlanif 1

[R1]ospf 1
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0]network 10.0.0.0 0.255.255.255
```

配置完成后，稍等片刻，待网络收敛后，测试网络的连通性。

```
[S2]ping -c 1 10.0.11.1
  PING 10.0.11.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.11.1: bytes=56 Sequence=1 ttl=255 time=1 ms

  --- 10.0.11.1 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[S2]ping -c 1 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.2.1: bytes=56 Sequence=1 ttl=254 time=1 ms

  --- 10.0.1.1 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

```
[S2]ping -c 1 10.0.12.2
  PING 10.0.12.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.2.2: bytes=56 Sequence=1 ttl=255 time=1 ms

  --- 10.0.12.2 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

步骤三. 配置 VRRP，实现网关冗余

S1配置VRRP，使用VRRP组1，默认优先级为100，实验中定义为105。

```
[S1]interface Vlanif 1
[S1-Vlanif1]vrrp vrid 1 virtual-ip 10.0.123.1
[S1-Vlanif1]vrrp vrid 1 priority 105

[S2]interface Vlanif 1
[S2-Vlanif1]vrrp vrid 1 virtual-ip 10.0.123.1
```

配置完成后，在R2和R3上测试它们与模拟的Internet服务器之间的通讯是否正常。

```
[R2]ping -c 1 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms

  --- 10.0.1.1 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 2/2/2 ms

[R3]ping -c 1 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=254 time=7 ms

  --- 10.0.1.1 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 7/7/7 ms
```

在S1上查看VRRP当前的状态信息。

```
[S1]display vrrp
  Vlanif1 | Virtual Router 1
    State : Master
    Virtual IP : 10.0.123.1
    Master IP : 10.0.123.2
    PriorityRun : 105
    PriorityConfig : 105
    MasterPriority : 105
    Preempt : YES   Delay time : 0
    TimerRun : 1
    TimerConfig : 1
    Auth type : NONE
    Virtual MAC :  0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Config track link-bfd down-number : 0
```

当前R2与R3都是通过S1将数据包发送至Internet的。关闭S1的VLANIF 1接口，然后测试网络是否能正常切换。

```
[S1]interface Vlanif 1
[S1-Vlanif1]shutdown
```

在R2与R3上测试它们与模拟的Internet服务器之间的通讯是否正常。

```
[R2]ping -c 1 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms

  --- 10.0.1.1 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
round-trip min/avg/max = 2/2/2 ms

[R3]ping -c 1 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms

  --- 10.0.1.1 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
```

```
    0.00% packet loss
    round-trip min/avg/max = 2/2/2 ms
```

此时相当于S1设备停止工作。查看S1与S2的VRRP状态。

```
[S1]display vrrp
  Vlanif1 | Virtual Router 1
    State : Initialize
    Virtual IP : 10.0.123.1
    Master IP : 0.0.0.0
    PriorityRun : 105
    PriorityConfig : 105
    MasterPriority : 0
    Preempt : YES   Delay time : 0
    TimerRun : 1
    TimerConfig : 1
    Auth type : NONE
    Virtual MAC :  0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Config track link-bfd down-number : 0

[S2]display vrrp
  Vlanif1 | Virtual Router 1
    State : Master
    Virtual IP : 10.0.123.1
    Master IP : 10.0.123.3
    PriorityRun : 100
    PriorityConfig : 100
    MasterPriority : 100
    Preempt : YES   Delay time : 0
    TimerRun : 1
    TimerConfig : 1
    Auth type : NONE
    Virtual MAC :  0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Config track link-bfd down-number : 0
```

步骤四. 跟踪接口状态

重新打开S1的VLANIF 1接口。并配置S1、S2均跟踪它们的G0/0/1接口

```
[S1]interface Vlanif 1
[S1-Vlanif1]undo shutdown
```

查看S1的VRRP状态。

```
[S1]display vrrp
  Vlanif1 | Virtual Router 1
    State : Master
    Virtual IP : 10.0.123.1
    Master IP : 10.0.123.2
    PriorityRun : 105
    PriorityConfig : 105
    MasterPriority : 105
    Preempt : YES   Delay time : 0
    TimerRun : 1
    TimerConfig : 1
    Auth type : NONE
    Virtual MAC :  0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Config track link-bfd down-number : 0
```

此时R2与R3通过S1发送数据给Internet。如果关闭S1的G0/0/1接口，或关闭R1的G0/0/1接口，网络将无法自动切换到通过S2发送数据给Internet。

关闭S1的G0/0/1接口

```
[S1]interface GigabitEthernet 0/0/1
[S1-GigabitEthernet0/0/1]shutdown
```

查看S1的VRRP状态信息

```
[S1]display vrrp brief
VRID State      Interface        Type   Virtual IP
--------------------------------------------------------
1    Master     Vlanif1          Normal  10.0.123.1
```

注：使用**brief**参数可以显示简略信息。

测试R2与Internet的连通性。

```
[R2]ping -c 1 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Request time out

  --- 10.0.1.1 ping statistics ---
```

```
    1 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss
```

显示无法正常通信。

重新打开S1的G0/0/1接口

```
[S1]interface GigabitEthernet 0/0/1
[S1-GigabitEthernet0/0/1]undo shutdown
```

S1和S2上配置VRRP的接口跟踪，定义跟踪G0/0/1接口，如果接口被关闭，则优先级降低10，这样的情况下，S2将抢占S1的VRRP主角色。

```
[S1]interface Vlanif 1
[S1-Vlanif1]vrrp vrid 1 track interface GigabitEthernet 0/0/1 reduced 10

[S2]interface Vlanif 1
[S2-Vlanif1]vrrp vrid 1 track interface GigabitEthernet 0/0/1 reduced 10
```

此时，测试网络的连通性。

网络正常时，R2可以与Internet服务器通讯。

```
[R2]ping -c 1 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=254 time=3 ms

  --- 10.0.1.1 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 3/3/3 ms
```

关闭S1的G0/0/1接口。

```
[S1]interface GigabitEthernet 0/0/1
[S1-GigabitEthernet0/0/1]shutdown
```

测试R2与Internet服务器之间的连通性。

```
[R2]ping -c 1 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=254 time=2 ms

  --- 10.0.1.1 ping statistics ---
    1 packet(s) transmitted
```

```
   1 packet(s) received
   0.00% packet loss
round-trip min/avg/max = 2/2/2 ms
```

通讯依然正常，查看S1的VRRP状态。

```
[S1]display vrrp
  Vlanif1 | Virtual Router 1
    State : Backup
    Virtual IP : 10.0.123.1
    Master IP : 10.0.123.3
    PriorityRun : 95
    PriorityConfig : 105
    MasterPriority : 100
    Preempt : YES   Delay time : 0
    TimerRun : 1
    TimerConfig : 1
    Auth type : NONE
    Virtual MAC :  0000-5e00-0101
    Check TTL : YES
    Config type : normal-vrrp
    Track IF : GigabitEthernet0/0/1   Priority reduced : 10
    IF state : DOWN
    Config track link-bfd down-number : 0
```

附加实验：思考并验证

在当前配置当中，实现的只是两台三层交换机之间的冗余，可以有效的避免单点故障。但是在日常使用中，只有一台三层交换机被使用，造成了资源的浪费。

请在当前拓扑图上，设计一种方案，确保冗余的情况下，实现负载分担功能。

最终设备配置

```
[S1]display current-configuration
#
 !Software Version V100R006C00SPC800
sysname S1
#
 vlan batch 1 to 3
#
```

```
interface Vlanif1
 ip address 10.0.123.2 255.255.255.0
 vrrp vrid 1 virtual-ip 10.0.123.1
 vrrp vrid 1 priority 105
 vrrp vrid 1 track interface GigabitEthernet0/0/1
#
interface Vlanif2
 ip address 10.0.11.1 255.255.255.0
#
interface GigabitEthernet0/0/1
 shutdown
 port link-type access
 port default vlan 2
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/2
 port link-type access
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/10
 port link-type trunk
 port trunk allow-pass vlan 2 to 4094
 ntdp enable
 ndp enable
 bpdu enable
#
interface NULL0
#
ospf 1
 silent-interface Vlanif1
 area 0.0.0.0
  network 10.0.0.0 0.255.255.255
#
user-interface con 0
user-interface vty 0 4
#
return
```

```
[S2]display current-configuration
#
 !Software Version V100R006C00SPC800
sysname S2
#
 vlan batch 1 to 3
#
interface Vlanif1
 ip address 10.0.123.3 255.255.255.0
 vrrp vrid 1 virtual-ip 10.0.123.1
 vrrp vrid 1 track interface GigabitEthernet0/0/1
#
interface Vlanif3
 ip address 10.0.12.1 255.255.255.0
#
interface GigabitEthernet0/0/1
 port link-type access
 port default vlan 3
 ntdp enable
 ndp enable
 bpdu enable
#
interface GigabitEthernet0/0/3
 port link-type access
 ntdp enable
 ndp enable
 bpdu enable
#
ospf 1
 silent-interface Vlanif1
 area 0.0.0.0
  network 10.0.0.0 0.255.255.255
#
user-interface con 0
user-interface vty 0 4
#
return


[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
```

```
#
interface GigabitEthernet0/0/1
 ip address 10.0.11.2 255.255.255.0
#
interface GigabitEthernet0/0/2
 ip address 10.0.12.2 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
ospf 1
 area 0.0.0.0
  network 10.0.0.0 0.255.255.255
#
user-interface con 0
user-interface vty 0 4
user-interface vty 16 20
#
return
```

```
[R2]display current-configuration
[V200R001C01SPC300]
#
 sysname R2
#
interface GigabitEthernet0/0/1
 ip address 10.0.123.4 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.123.1
#
user-interface con 0
user-interface vty 0 4
user-interface vty 16 20
#
return
```

```
[R3]display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
```

```
interface GigabitEthernet0/0/2
 ip address 10.0.123.5 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.123.1
#
user-interface con 0
user-interface vty 0 4
user-interface vty 16 20
#
return
```

第八章 广域网技术

实验 8-1 HDLC 与 PPP 配置

学习目的

- 了解常见的广域网技术
- 理解PPP协议的工作原理
- 掌握在串行链路上配置HDLC的方法
- 掌握查看和修改串行链路时钟频率的方法
- 掌握在串行链路上配置PPP的方法
- 掌握在PPP链路上配置PAP认证的方法
- 掌握在PPP链路上配置CHAP认证的方法
- 掌握在PPP链路上协商的过程

拓扑图

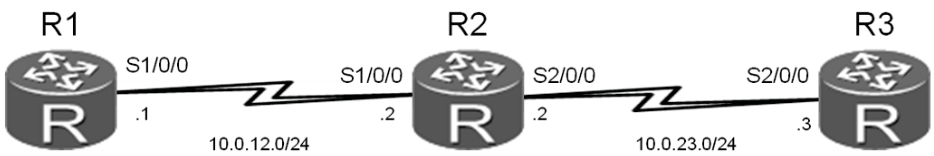


图8.1 HDLC与PPP配置

场景

你是公司的网络管理员。公司的总部有一台路由器R1，R2和R3分别是其他两个分部的路由器。现在你需要将总部和分部连接到同一个网络。广域网链路上你尝试使用HDLC和PPP协议，在定义PPP协议时采用了不同的认证方式保证安全。

学习任务

步骤一. 基本配置与 IP 编址

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface Serial 1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 24
[R2-Serial1/0/0]quit
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]ip address 10.0.23.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface Serial 2/0/0
[R3-Serial2/0/0]ip address 10.0.23.3 24
```

步骤二. 将串口封装类型改为 HDLC

```
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]link-protocol hdlc
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R1-Serial1/0/0]

[R2]interface Serial 1/0/0
[R2-Serial1/0/0]link-protocol hdlc
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R2-Serial1/0/0]quit
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]link-protocol hdlc
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R2-Serial2/0/0]
```

```
[R3]interface Serial 2/0/0
[R3-Serial2/0/0]link-protocol hdlc
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R3-Serial2/0/0]
```

配置完成后，以R1为例查看状态。

```
[R1]display interface Serial1/0/0
Serial1/0/0 current state : UP
Line protocol current state : UP
Last line protocol up time : 2011-10-09 14:42:26
Description:HUAWEI, AR Series, Serial1/0/0 Interface
Route Port,The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is 10.0.12.1/24
Link layer protocol is nonstandard HDLC
Last physical up time   : 2011-10-09 14:39:44
Last physical down time : 2011-10-09 14:39:43
Current system time: 2011-10-09 14:43:14
Physical layer is synchronous, Baudrate is 64000 bps
Interface is DCE, Cable type is V35, Clock mode is DCECLK
Last 300 seconds input rate 2 bytes/sec 16 bits/sec 0 packets/sec
Last 300 seconds output rate 2 bytes/sec 16 bits/sec 0 packets/sec
Input: 257 packets, 3856 bytes
  broadcasts:       0,  multicasts:         0
  errors:           0,  runts:              0,  giants:         0
  CRC:          0,  align errors:       0,  overruns:       0
  dribbles:             0,  aborts:             0,  no buffers:         0
  frame errors:         0
Output: 252 packets, 3184 bytes
  errors:               0,  underruns:      0,  collisions:       0
  deferred:             0
DCD=UP DTR=UP DSR=UP RTS=UP CTS=UP

    Input bandwidth utilization  : 0.05%
    Output bandwidth utilization : 0.05%
```

确认接口的物理状态和协议状态为“UP”后，测试直连链路的连通性。

```
 [R2]ping 10.0.12.1
  PING 10.0.12.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.12.1: bytes=56 Sequence=1 ttl=255 time=44 ms
    Reply from 10.0.12.1: bytes=56 Sequence=2 ttl=255 time=39 ms
    Reply from 10.0.12.1: bytes=56 Sequence=3 ttl=255 time=39 ms
```

```
    Reply from 10.0.12.1: bytes=56 Sequence=4 ttl=255 time=40 ms
    Reply from 10.0.12.1: bytes=56 Sequence=5 ttl=255 time=39 ms

  --- 10.0.12.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 39/40/44 ms

[R2]ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=255 time=44 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=255 time=39 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=255 time=39 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=255 time=40 ms
    Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=255 time=39 ms

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 39/40/44 ms
```

步骤三. 配置 RIPv2 协议

```
[R1]rip
[R1-rip-1]version 2
[R1-rip-1]network 10.0.0.0

[R2]rip
[R2-rip-1]version 2
[R2-rip-1]network 10.0.0.0

[R3]rip
[R3-rip-1]version 2
[R3-rip-1]network 10.0.0.0
```

配置完成后，查看路由信息学习是否完整。

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
```

```
Routing Tables: Public
       Destinations : 8       Routes : 8

Destination/Mask    Proto   Pre  Cost     Flags NextHop       Interface

10.0.12.0/24  Direct  0    0          D   10.0.12.1      Serial1/0/0
10.0.12.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
10.0.12.255/32  Direct  0    0        D   127.0.0.1      InLoopBack0
10.0.23.0/24  RIP     100  1          D   10.0.12.2      Serial1/0/0
127.0.0.0/8   Direct  0    0          D   127.0.0.1      InLoopBack0
127.0.0.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
255.255.255.255/32  Direct  0    0    D   127.0.0.1      InLoopBack0
```

确认有相应的路由信息通过RIP协议学习到。

在R1上使用**ping**命令测试R1与R3的连通性。

```
[R1]ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=254 time=44 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=254 time=39 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=254 time=39 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=254 time=40 ms
    Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=254 time=39 ms

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 39/40/44 ms
```

步骤四. 查看串口连接的线缆类型，接口状态，时钟频率，并修改时钟频率

```
[R2]display interface Serial1/0/0
Serial1/0/0 current state : UP
Line protocol current state : UP
Last line protocol up time : 2011-10-09 16:25:55
Description:HUAWEI, AR Series, Serial1/0/0 Interface
Route Port,The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is 10.0.12.2/24
```

```
Link layer protocol is nonstandard HDLC
Last physical up time   : 2011-10-09 16:25:55
Last physical down time : 2011-10-09 16:25:55
Current system time: 2011-10-09 16:52:14
Physical layer is synchronous, Virtualbaudrate is 64000 bps
Interface is DTE, Cable type is V35, Clock mode is TC
Last 300 seconds input rate 4 bytes/sec 32 bits/sec 0 packets/sec
Last 300 seconds output rate 4 bytes/sec 32 bits/sec 0 packets/sec
Input: 223 packets, 7152 bytes
  broadcasts:       0,  multicasts:         0
  errors:               0,  runts:          0,  giants:         0
  CRC:              0,  align errors:       0,  overruns:            0
  dribbles:             0,  aborts:         0,  no buffers:          0
  frame errors:         0
Output: 227 packets, 6674 bytes
  errors:              0,  underruns:       0,  collisions:          0
  deferred:             0
DCD=UP DTR=UP DSR=UP RTS=UP CTS=UP

    Input bandwidth utilization  : 0.05%
    Output bandwidth utilization : 0.19%
```

如上显示R2的S1/0/0接口连接DTE线缆，时钟频率为64000bps。可以推断出R1的S1/0/0接口连接的是DCE线缆。

时钟频率与实际带宽直接关联，并由DCE端控制。

现在修改R1与R2之间链路的时钟频率为128000bps。修改必须在DCE端进行，在R1上进行。

```
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]baudrate 128000
```

完成后进行查看。

```
[R1]display interface Serial1/0/0
Serial1/0/0 current state : UP
Line protocol current state : UP
Last line protocol up time : 2011-10-10 11:56:41
Description:HUAWEI, AR Series, Serial1/0/0 Interface
Route Port,The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is 10.0.12.1/24
Link layer protocol is PPP
LCP opened, IPCP opened
Last physical up time   : 2011-10-10 11:56:38
```

```
Last physical down time : 2011-10-10 11:53:32
Current system time: 2011-10-10 13:58:43
Physical layer is synchronous, Baudrate is 128000 bps
Interface is DCE, Cable type is V35, Clock mode is DCECLK
Last 300 seconds input rate 5 bytes/sec 40 bits/sec 0 packets/sec
Last 300 seconds output rate 2 bytes/sec 16 bits/sec 0 packets/sec
Input: 3471 packets, 66408 bytes
  broadcasts:          0,  multicasts:          0
  errors:             0,  runts:              0,  giants:             0
  CRC:               0,  align errors:        0,  overruns:           0
  dribbles:           0,  aborts:             0,  no buffers:         0
  frame errors:        0
Output: 3218 packets, 40326 bytes
  errors:             0,  underruns:          0,  collisions:         0
  deferred:           0
DCD=UP DTR=UP DSR=UP RTS=UP CTS=UP

    Input bandwidth utilization  : 0.03%
    Output bandwidth utilization : 0.03%
```

步骤五. 修改 R1 与 R2 之间的串口、R2 与 R3 之间的串口封装类型为 PPP

配置使用PPP封装，注意当链路两端的封装形式不一致时，接口状态会出现“down”的情况。

```
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]link-protocol ppp
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R1-Serial1/0/0]

[R2]interface Serial 1/0/0
[R2-Serial1/0/0]link-protocol ppp
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R2-Serial1/0/0]quit
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]link-protocol ppp
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R2-Serial2/0/0]

[R3]interface Serial 2/0/0
```

```
[R3-Serial2/0/0]link-protocol ppp
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R3-Serial2/0/0]
```

配置完成后，注意测试链路的连通性。

```
[R2]ping 10.0.12.1
  PING 10.0.12.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.12.1: bytes=56 Sequence=1 ttl=255 time=22 ms
    Reply from 10.0.12.1: bytes=56 Sequence=2 ttl=255 time=27 ms
    Reply from 10.0.12.1: bytes=56 Sequence=3 ttl=255 time=27 ms
    Reply from 10.0.12.1: bytes=56 Sequence=4 ttl=255 time=27 ms
    Reply from 10.0.12.1: bytes=56 Sequence=5 ttl=255 time=27 ms

  --- 10.0.12.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 22/26/27 ms

[R2]ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=255 time=35 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=255 time=40 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=255 time=40 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=255 time=40 ms
    Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=255 time=40 ms

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 35/39/40 ms
```

如果无法**Ping**通，请查看接口状态，观察协议状态是否正常。

```
[R1]display interface Serial1/0/0
Serial1/0/0 current state : UP
Line protocol current state : UP
Last line protocol up time : 2011-10-10 16:26:28
Description:HUAWEI, AR Series, Serial1/0/0 Interface
Route Port,The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is 10.0.12.1/24
Link layer protocol is PPP
```

```
LCP opened, IPCP opened
Last physical up time   : 2011-10-10 16:26:25
Last physical down time : 2011-10-10 16:26:04
Current system time: 2011-10-10 16:31:06
Physical layer is synchronous, Baudrate is 128000 bps
Interface is DCE, Cable type is V35, Clock mode is DCECLK
Last 300 seconds input rate 5 bytes/sec 40 bits/sec 0 packets/sec
Last 300 seconds output rate 2 bytes/sec 16 bits/sec 0 packets/sec
Input: 5600 packets, 116506 bytes
  broadcasts:          0,  multicasts:          0
  errors:              0,  runts:               0,  giants:             0
  CRC:                 0,  align errors:        0,  overruns:           0
  dribbles:            0,  aborts:              0,  no buffers:         0
  frame errors:        0
Output: 5046 packets, 63250 bytes
  errors:              0,  underruns:           0,  collisions:         0
  deferred:            0
DCD=UP DTR=UP DSR=UP RTS=UP CTS=UP

    Input bandwidth utilization  : 0.03%
    Output bandwidth utilization : 0.03%
```

步骤六. 观察路由表路由条目出现的变化

在PPP配置完成后，设备将在第二层使用该协议建立连接。同时，会向对方设备发送主机路由，路由信息包括自己接口的IP地址，掩码为32位。

以R2为例，可以查看到R1和R3发送的主机路由。

```
[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 12      Routes : 12

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.12.0/24  Direct  0    0           D   10.0.12.2       Serial1/0/0
      10.0.12.1/32  Direct  0    0           D   10.0.12.1       Serial1/0/0
      10.0.12.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.23.0/24  Direct  0    0           D   10.0.23.2       Serial2/0/0
      10.0.23.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

```
     10.0.23.3/32  Direct  0    0           D   10.0.23.3      Serial2/0/0
    10.0.23.255/32  Direct  0    0           D   127.0.0.1      InLoopBack0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1      InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1      InLoopBack0
```

思考这两条路由信息的来源、作用。有时间的学员，可以做如下验证：

1、封装协议定义为HDLC时，是否有这样的路由？

2、如果R1的S1/0/0接口IP地址与R2的S1/0/0接口IP地址不在同一个网段，封装协议定义为HDLC时能否相互通讯？封装定义为PPP时能否相互通讯？

步骤七. 定义 R1 与 R2 之间的 PPP 链路使用 PAP 认证

定义R1为认证服务器，R2向R1发送认证请求。

在R1上配置PAP认证。

```
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ppp authentication-mode pap
[R1-Serial1/0/0]quit
[R1]aaa
[R1-aaa]local-user huawei password simple hello
 info: A new user added
[R1-aaa]local-user huawei service-type ppp
```

在R2上配置PAP认证。

```
[R2]interface Serial 1/0/0
[R2-Serial1/0/0]shutdown
[R2-Serial1/0/0]ppp pap local-user huawei password simple hello
[R2-Serial1/0/0]undo shutdown
```

配置完成后，检测R1与R2之间的连通性。

步骤八. 定义 R2 与 R3 之间的 PPP 链路使用 CHAP 认证

定义R3为认证服务器，向R2提出认证需求。

```
[R3]interface Serial 2/0/0
[R3-Serial2/0/0]ppp authentication-mode chap
[R3-Serial2/0/0]shutdown
[R3-Serial2/0/0]quit
[R3]aaa
[R3-aaa]local-user user1 password cipher huawei
 info: A new user added
[R3-aaa]local-user user1 service-type ppp
[R3-aaa]quit
[R3]interface Serial 2/0/0
[R3-Serial2/0/0]undo shutdown
```

注意，此时R3会有如下提示。

```
Oct 10 2011 16:46:03+00:00 R3 %%01PPP/4/PEERNOCHAP(l)[9]:On the interface
Serial2/0/0, authentication failed and PPP link was closed because CHAP was
disabled on the peer.
Oct 10 2011 16:46:03+00:00 R3 %%01PPP/4/RESULTERR(l)[10]:On the interface
Serial2/0/0, LCP negotiation failDCD=UP DTR=UP DSR=UP RTS=UP CTS=UP
```

表示R3在使用PPP与对端验证时失败。

将R2配置为CHAP客户端。

```
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]ppp chap user user1
[R2-Serial2/0/0]ppp chap password cipher huawei
```

配置完成后，接口状态将转变为“UP”状态。使用**ping**命令测试如下

```
[R2]ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=255 time=35 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=255 time=41 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=255 time=41 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=255 time=41 ms
    Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=255 time=41 ms

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 35/39/41 ms
```

步骤九. 使用debug命令查看R2和R3之间使用CHAP建立PPP连接的协商过程

以R2为例查看R2与R3建立PPP连接时的协商情况。为看到完整情况，首先关闭R2的S2/0/0接口，然后启动**debug**命令，再打开接口，即可看到完整协商过程。

首先关闭R2物理接口.

```
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]shutdown
```

在R2上开启**ppp chap**的**debug**命令，注意默认**debug**产生的信息是不会输出的 ,需要使用命令**terminal debugging**使**debug**的信息在Console口输出。

```
[R2-Serial2/0/0]return
<R2>debugging ppp chap all
<R2>terminal debugging
Info: Current terminal debugging is on.
```

打开R2的物理接口。

```
<R2>system-view
Enter system view, return user view with Ctrl+Z.
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]undo shutdown
```

此时可以看到Console口输出相应的**debug**信息，如下

```
  PPP State Change:
      Serial2/0/0 CHAP : Initial --> ListenChallenge
Oct 10 2011 17:54:48.830.1+00:00 R2 PPP/7/debug2:
  PPP Packet:
      Serial2/0/0 Input  CHAP(c223) Pkt, Len 25
      State ListenChallenge, code Challenge(01), id 1, len 21
      Value_Size:  16  Value: 53 e3 a6 26 1b 54 e5 e2 a1 ed 90 87 94  3 f0  1
      Name:
Oct 10 2011 17:54:48.830.2+00:00 R2 PPP/7/debug2:
  PPP Event:
      Serial2/0/0 CHAP Receive Challenge Event
      state ListenChallenge
Oct 10 2011 17:54:48.830.3+00:00 R2 PPP/7/debug2:
  PPP Packet:
      Serial2/0/0 Output CHAP(c223) Pkt, Len 37
```

```
    State ListenChallenge, code Response(02), id 1, len 33
    Value_Size:  16  Value: 4b  6 73 d1 48 c2 55 8d da a6 c7 3e 21 e9 44 48
    Name: user1
Oct 10 2011 17:54:48.830.4+00:00 R2 PPP/7/debug2:
  PPP State Change:
    Serial2/0/0 CHAP : ListenChallenge --> SendResponse
Oct 10 2011 17:54:48.850.1+00:00 R2 PPP/7/debug2:
  PPP Packet:
    Serial2/0/0 Input  CHAP(c223) Pkt, Len 20
    State SendResponse, code SUCCESS(03), id 1, len 16
    Message: Welcome to .
Oct 10 2011 17:54:48.850.2+00:00 R2 PPP/7/debug2:
  PPP Event:
    Serial2/0/0 CHAP Receive Success Event
    state SendResponse
Oct 10 2011 17:54:48.850.3+00:00 R2 PPP/7/debug2:
  PPP State Change:
    Serial2/0/0 CHAP : SendResponse --> ClientSuccess
```

注意协商状态的变化和发送的信息。

有时间的学生，可以使用**debugging ppp pap all**命令查看R1和R2之间使用PAP认证时，PPP协商的情况，并与上面的信息对比，分析PAP与CHAP认证的过程的差异。

附加实验：思考并验证

分析CHAP的认证流程，思考为什么CHAP比PAP更加安全？

最终设备配置

```
[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
aaa
 authentication-scheme default
```

```
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password simple admin
 local-user admin service-type http
 local-user huawei password simple hello
 local-user huawei service-type ppp
#
interface Serial1/0/0
 link-protocol ppp
 ppp authentication-mode pap
 ip address 10.0.12.1 255.255.255.0
 baudrate 128000
#
rip 1
 version 2
 network 10.0.0.0
#
return

[R2]display current-configuration
[V200R001C01SPC300]
#
 sysname R2
#
aaa
 authentication-scheme default
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 local-user admin password simple admin
 local-user admin service-type http
#
interface Serial1/0/0
 link-protocol ppp
 ppp pap local-user huawei password simple hello

 ip address 10.0.12.2 255.255.255.0
#
interface Serial2/0/0
 link-protocol ppp
```

```
 ppp chap user user1
 ppp chap password cipher N`C55QK<`=/Q=^Q`MAF4<1!!
 ip address 10.0.23.2 255.255.255.0
#
rip 1
 version 2
 network 10.0.0.0
#
return

<R3>display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
aaa
 authentication-scheme default
 authentication-scheme system
 authorization-scheme default
 accounting-scheme default
 domain default
 domain default_admin
 domain system
 local-user admin password simple admin
 local-user admin service-type http
local-user user1 password cipher N`C55QK<`=/Q=^Q`MAF4<1!!
 local-user user1 service-type ppp
#
interface Serial2/0/0
 link-protocol ppp
 ppp authentication-mode chap
 ip address 10.0.23.3 255.255.255.0
#
rip 1
 version 2
 network 10.0.0.0
#
return
```

实验 8-2 帧中继（背靠背）配置

学习目的

- 了解帧中继中PVC的功能和作用
- 理解帧中继协议的工作原理
- 掌握在串行链路上配置Frame Relay的方法
- 掌握在帧中继网络上手动定义IP与DLCI号码映射的方法
- 掌握在帧中继网络上运行RIP的配置方法
- 掌握在帧中继网络上运行OSPF的配置方法

拓扑图

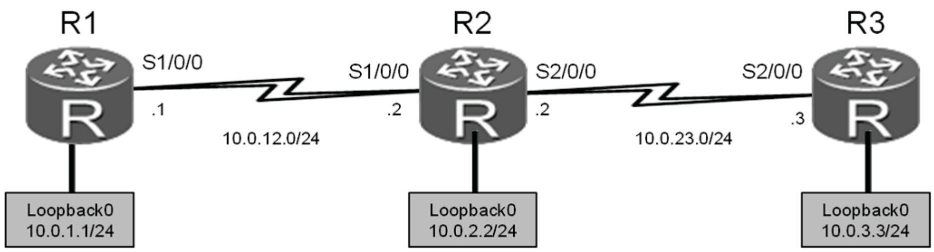


图8.2 帧中继（背靠背）配置实验拓扑图

场景

你是你们公司的网络管理员。公司的总部有一台路由器R1，R2和R3分别是其他两个分部的路由器。现在你需要将总部和分部连接到同一个网络。广域网链路上你尝试使用帧中继协议，在定义FR的DLCI与IP地址对应关系时采用了不同的二层和三层地址映射方式。

学习任务

步骤一. 基本配置与 IP 编址

```
<Huawei>system-view
[Huawei]sysname R1
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]ip address 10.0.12.1 24
[R1-Serial1/0/0]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24

<Huawei>system-view
[Huawei]sysname R2
[R2]int Serial 1/0/0
[R2-Serial1/0/0]ip address 10.0.12.2 24
[R2-Serial1/0/0]interface loopback 0
[R2-LoopBack0]ip address 10.0.2.2 24
[R2-LoopBack0]interface Serial 2/0/0
[R2-Serial2/0/0]ip address 10.0.23.2 24

<Huawei>system-view
[Huawei]sysname R3
[R3]int Serial 2/0/0
[R3-Serial2/0/0]ip address 10.0.23.3 24
[R3-Serial2/0/0]interface loopback 0
[R3-LoopBack0]ip address 10.0.3.3 24
```

完成后测试网络的连通性。

```
[R2]ping 10.0.12.1
 PING 10.0.12.1: 56  data bytes, press CTRL_C to break
   Reply from 10.0.12.1: bytes=56 Sequence=1 ttl=255 time=36 ms
   Reply from 10.0.12.1: bytes=56 Sequence=2 ttl=255 time=32 ms
   Reply from 10.0.12.1: bytes=56 Sequence=3 ttl=255 time=32 ms
   Reply from 10.0.12.1: bytes=56 Sequence=4 ttl=255 time=32 ms
   Reply from 10.0.12.1: bytes=56 Sequence=5 ttl=255 time=32 ms

 --- 10.0.12.1 ping statistics ---
   5 packet(s) transmitted
   5 packet(s) received
   0.00% packet loss
   round-trip min/avg/max = 32/32/36 ms
```

```
[R2]ping 10.0.23.3
  PING 10.0.23.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.3: bytes=56 Sequence=1 ttl=255 time=41 ms
    Reply from 10.0.23.3: bytes=56 Sequence=2 ttl=255 time=37 ms
    Reply from 10.0.23.3: bytes=56 Sequence=3 ttl=255 time=37 ms
    Reply from 10.0.23.3: bytes=56 Sequence=4 ttl=255 time=37 ms
    Reply from 10.0.23.3: bytes=56 Sequence=5 ttl=255 time=37 ms

  --- 10.0.23.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 37/37/41 ms
```

步骤二. 配置 R1 与 R2 之间使用帧中继的背靠背形式，使用静态地址映射

配置帧中继时，串口线缆的DCE端与DTE端配置不同，首先查看是R1还是R2连接到串口线缆的DCE段。

```
[R1]display interface Serial1/0/0
Serial1/0/0 current state : UP
Line protocol current state : UP
Last line protocol up time : 2011-10-11 14:40:34
Description:HUAWEI, AR Series, Serial1/0/0 Interface
Route Port,The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is 10.0.12.1/24
Link layer protocol is PPP
LCP opened, IPCP opened
Last physical up time   : 2011-10-11 14:40:34
Last physical down time : 2011-10-11 14:40:33
Current system time: 2011-10-11 14:40:38
Physical layer is synchronous, Baudrate is 64000 bps
Interface is DCE, Cable type is V35, Clock mode is DCECLK
Last 300 seconds input rate 4 bytes/sec 32 bits/sec 0 packets/sec
Last 300 seconds output rate 5 bytes/sec 40 bits/sec 0 packets/sec
Input: 3564 packets, 50438 bytes
  broadcasts:          0,  multicasts:          0
  errors:              0,  runts:               0,  giants:              0
  CRC:                 0,  align errors:        0,  overruns:            0
```

```
  dribbles:            0,  aborts:              0,  no buffers:           0
  frame errors:         0
Output: 3597 packets, 43666 bytes
  errors:              0,  underruns:           0,  collisions:           0
  deferred:            0
DCD=UP DTR=UP DSR=UP RTS=UP CTS=UP

    Input bandwidth utilization  : 0.28%
    Output bandwidth utilization : 0.28%
```

如以上显示R1的S1/0/0接口连接到了串行线缆的DCE端。

```
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]link-protocol fr
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R1-Serial1/0/0]fr interface-type dce
[R1-Serial1/0/0]undo fr inarp
[R1-Serial1/0/0]fr dlci 102
[R1-fr-dlci-Serial1/0/0-102]quit
[R1-Serial1/0/0]fr map ip 10.0.12.2 102 broadcast
```

R2端为串行线缆的DTE端。

```
[R2]interface Serial 1/0/0
[R2-Serial1/0/0]link-protocol fr
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R2-Serial1/0/0]fr interface-type dte
[R2-Serial1/0/0]undo fr inarp
[R2-Serial1/0/0]fr map ip 10.0.12.1 102 broadcast
```

配置完成后，在此测试R1与R2的连通性。

```
[R2]ping 10.0.12.1
  PING 10.0.12.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.12.1: bytes=56 Sequence=1 ttl=255 time=38 ms
    Reply from 10.0.12.1: bytes=56 Sequence=2 ttl=255 time=34 ms
    Reply from 10.0.12.1: bytes=56 Sequence=3 ttl=255 time=34 ms
    Reply from 10.0.12.1: bytes=56 Sequence=4 ttl=255 time=34 ms
    Reply from 10.0.12.1: bytes=56 Sequence=5 ttl=255 time=34 ms

  --- 10.0.12.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 34/34/38 ms
```

注意，如果在配置帧中继之前，在步骤一的最后，测试R1与R2通讯正常。如果通讯不正常，则错误出现在帧中继的配置上面，可以使用如下方式进行故障排除。

以R1为例，注意以下标记的信息，并与R2对应信息对比。

```
[R1]display fr map-info
Map Statistics for interface Serial1/0/0 (DCE)
  DLCI = 102, IP 10.0.12.2, Serial1/0/0
    create time = 2011/10/11 14:44:45, status = ACTIVE
    encapsulation = ietf, vlink = 6, broadcast

[R1]display interface Serial1/0/0
Serial1/0/0 current state : UP
Line protocol current state : UP
Last line protocol up time : 2011-10-11 14:44:35
Description:HUAWEI, AR Series, Serial1/0/0 Interface
Route Port,The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is 10.0.12.1/24
Link layer protocol is FR IETF
  LMI DLCI is 0, LMI type is Q.933a, frame relay DCE
  LMI status enquiry received 21, LMI status sent 21
  LMI status enquiry timeout 9, LMI message discarded 2
Last physical up time   : 2011-10-11 14:44:25
Last physical down time : 2011-10-11 14:44:25
Current system time: 2011-10-11 14:48:04
Physical layer is synchronous, Baudrate is 64000 bps
Interface is DCE, Cable type is V35, Clock mode is DCECLK
Last 300 seconds input rate 12 bytes/sec 96 bits/sec 0 packets/sec
Last 300 seconds output rate 10 bytes/sec 80 bits/sec 0 packets/sec
Input: 3712 packets, 54496 bytes
  broadcasts:          0,  multicasts:          0
  errors:              0,  runts:               0,  giants:              0
  CRC:                 0,  align errors:        0,  overruns:            0
  dribbles:            0,  aborts:              0,  no buffers:          0
  frame errors:        0
Output: 3727 packets, 47136 bytes
  errors:              0,  underruns:           0,  collisions:          0
  deferred:            0
DCD=UP DTR=UP DSR=UP RTS=UP CTS=UP

    Input bandwidth utilization  : 0.08%
Output bandwidth utilization : 0.08%
```

```
[R1]display fr lmi-info interface Serial 1/0/0
Frame relay LMI statistics for interface Serial1/0/0 (DCE, Q933)
  T392DCE = 15, N392DCE = 3, N393DCE = 4
  in status enquiry = 31, out status = 31
  status enquiry timeout = 9, discarded messages = 2
```

步骤三. 配置 R2 与 R3 之间使用帧中继的背靠背形式，使用动态地址映射

配置帧中继时，串口线缆的DCE端与DTE端配置不同。

查看是R2还是R3连接到串口线缆的DCE段。

```
[R3]display interface Serial2/0/0
Serial2/0/0 current state : UP
Line protocol current state : UP
Last line protocol up time : 2011-10-11 14:31:29
Description:HUAWEI, AR Series, Serial2/0/0 Interface
Route Port,The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is 10.0.23.3/24
Link layer protocol is PPP
LCP opened, IPCP opened
Last physical up time   : 2011-10-11 09:43:20
Last physical down time : 2011-10-11 09:43:19
Current system time: 2011-10-11 14:56:16
Physical layer is synchronous, Baudrate is 64000 bps
Interface is DCE, Cable type is V24, Clock mode is DCECLK
Last 300 seconds input rate 2 bytes/sec 16 bits/sec 0 packets/sec
Last 300 seconds output rate 2 bytes/sec 16 bits/sec 0 packets/sec
Input: 3765 packets, 53110 bytes
  broadcasts:          0,  multicasts:          0
  errors:              0,  runts:               0,  giants:              0
  CRC:                 0,  align errors:        0,  overruns:            0
  dribbles:            0,  aborts:              0,  no buffers:          0
  frame errors:        0
Output: 3766 packets, 45590 bytes
  errors:              0,  underruns:           0,  collisions:          0
  deferred:            0
DCD=UP DTR=UP DSR=UP RTS=UP CTS=UP

    Input bandwidth utilization  : 0.06%
    Output bandwidth utilization : 0.05%
```

如以上显示R3的S2/0/0接口连接到了DCE端。

```
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]link-protocol fr
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R2-Serial2/0/0]fr interface-type dte
[R2-Serial2/0/0]fr inarp
```

R3端为DCE。

```
[R3]interface Serial 2/0/0
[R3-Serial2/0/0]link-protocol fr
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R3-Serial2/0/0]fr interface-type dce
[R3-Serial2/0/0]fr dlci 203
[R3-fr-dlci-Serial2/0/0-203]quit
[R3-Serial2/0/0]fr inarp
```

配置完成后，测试R2与R3之间的连通性。

```
[R3]ping 10.0.23.2
  PING 10.0.23.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.2: bytes=56 Sequence=1 ttl=255 time=40 ms
    Reply from 10.0.23.2: bytes=56 Sequence=2 ttl=255 time=35 ms
    Reply from 10.0.23.2: bytes=56 Sequence=3 ttl=255 time=35 ms
    Reply from 10.0.23.2: bytes=56 Sequence=4 ttl=255 time=35 ms
    Reply from 10.0.23.2: bytes=56 Sequence=5 ttl=255 time=35 ms

  --- 10.0.23.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 35/36/40 ms
```

如果无法正常通讯，这可以参照如下命令输出进行故障排除。

```
[R3]display interface Serial2/0/0
Serial2/0/0 current state : UP
Line protocol current state : UP
Last line protocol up time : 2011-10-11 15:02:01
Description:HUAWEI, AR Series, Serial2/0/0 Interface
Route Port,The Maximum Transmit Unit is 1500, Hold timer is 10(sec)
Internet Address is 10.0.23.3/24
Link layer protocol is FR IETF
```

```
  LMI DLCI is 0, LMI type is Q.933a, frame relay DCE
  LMI status enquiry received 28, LMI status sent 28
  LMI status enquiry timeout 0, LMI message discarded 8
Last physical up time   : 2011-10-11 15:01:31
Last physical down time : 2011-10-11 15:01:30
Current system time: 2011-10-11 15:06:36
Physical layer is synchronous, Baudrate is 64000 bps
Interface is DCE, Cable type is V24, Clock mode is DCECLK
Last 300 seconds input rate 12 bytes/sec 96 bits/sec 0 packets/sec
Last 300 seconds output rate 12 bytes/sec 96 bits/sec 0 packets/sec
Input: 3974 packets, 58123 bytes
  broadcasts:          0,  multicasts:          0
  errors:              0,  runts:               0,  giants:             0
  CRC:                 0,  align errors:        0,  overruns:           0
  dribbles:            0,  aborts:              0,  no buffers:         0
  frame errors:        0
Output: 3957 packets, 50073 bytes
  errors:              0,  underruns:           0,  collisions:         0
  deferred:            0
DCD=UP DTR=UP DSR=UP RTS=UP CTS=UP

    Input bandwidth utilization  : 0.11%
    Output bandwidth utilization : 0.10%

[R3]display fr lmi-info
Frame relay LMI statistics for interface Serial2/0/0 (DCE, Q933)
  T392DCE = 15, N392DCE = 3, N393DCE = 4
  in status enquiry = 31, out status = 31
  status enquiry timeout = 0, discarded messages = 8

[R3]display fr map-info
Map Statistics for interface Serial2/0/0 (DCE)
  DLCI = 203, IP INARP 10.0.23.2, Serial2/0/0
    create time = 2011/10/11 15:02:21, status = ACTIVE
    encapsulation = ietf, vlink = 2, broadcast
```

注意以上标记的信息，并与R2对应信息对比。

步骤四. 配置 R1 与 R2 之间运行 RIPv2，手动定义邻居关系

```
[R1]rip
```

```
[R1-rip-1]version 2
[R1-rip-1]network 10.0.0.0
[R1-rip-1]undo summary

[R2]rip
[R2-rip-1]version 2
[R2-rip-1]network 10.0.0.0
[R2-rip-1]undo summary
```

在R1上查看路由信息。

```
[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 13       Routes : 13

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.1.0/24  Direct  0    0           D   10.0.1.1        LoopBack0
      10.0.1.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.1.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.2.0/24  RIP     100  1           D   10.0.12.2       Serial1/0/0
     10.0.12.0/24  Direct  0    0           D   10.0.12.1       Serial1/0/0
     10.0.12.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.12.2/32  Direct  0    0           D   10.0.12.2       Serial1/0/0
   10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.23.0/24  RIP     100  1           D   10.0.12.2       Serial1/0/0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

如上文所示R1已经学到了路由信息。在R1上测试网络的连通情况。

```
[R1]ping 10.0.23.2
  PING 10.0.23.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.23.2: bytes=56 Sequence=1 ttl=255 time=33 ms
    Reply from 10.0.23.2: bytes=56 Sequence=2 ttl=255 time=39 ms
    Reply from 10.0.23.2: bytes=56 Sequence=3 ttl=255 time=39 ms
    Reply from 10.0.23.2: bytes=56 Sequence=4 ttl=255 time=39 ms
    Reply from 10.0.23.2: bytes=56 Sequence=5 ttl=255 time=39 ms

  --- 10.0.23.2 ping statistics ---
```

```
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 33/37/39 ms
```

显示通讯正常。

注意此时R3未运行任何协议，R1将无法于R3通讯。

此时R1与R2运行RIP v2协议，但是由于网络支持广播，所以可以自动相互发送路由信息。

网络对广播支持的查看，以R2为例。

```
[R2]display fr map-info interface Serial 1/0/0
Map Statistics for interface Serial1/0/0 (DTE)
  DLCI = 102, IP 10.0.12.1, Serial1/0/0
    create time = 2011/10/11 15:12:15, status = ACTIVE
    encapsulation = ietf, vlink = 11, broadcast
```

修改R1与R2配置，关闭对广播的支持。

```
[R1]interface Serial 1/0/0
[R1-Serial1/0/0]undo fr map ip 10.0.12.2 102
[R1-Serial1/0/0]fr map ip 10.0.12.2 102

[R2]interface Serial 1/0/0
[R2-Serial1/0/0]undo fr map ip 10.0.12.1 102
[R2-Serial1/0/0]fr map ip 10.0.12.1 102
```

为使R1与R2刷新路由学习情况，需要将其中一个设备的接口关闭然后再打开。这里以R2为例。

```
[R2-Serial1/0/0]shutdown
[R2-Serial1/0/0]undo shutdown
```

完成后，再查看路由信息，以R2为例。

```
[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 15      Routes : 15

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.2.0/24  Direct  0    0           D   10.0.2.2        LoopBack0
```

```
      10.0.2.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.2.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.12.0/24  Direct  0    0           D   10.0.12.2       Serial1/0/0
      10.0.12.1/32  Direct  0    0           D   10.0.12.1       Serial1/0/0
      10.0.12.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.23.0/24  Direct  0    0           D   10.0.23.2       Serial2/0/0
      10.0.23.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.23.3/32  Direct  0    0           D   10.0.23.3       Serial2/0/0
    10.0.23.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

注意，此时，由于网络不支持广播，R1与R2无法相互交流路由信息。使用**ping**测试。

```
[R2]ping 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss
```

此时网络不支持广播，以R2为例。

```
[R2]display fr map-info interface Serial 1/0/0
Map Statistics for interface Serial1/0/0 (DTE)
  DLCI = 102, IP 10.0.12.1, Serial1/0/0
    create time = 2011/10/11 15:22:22, status = ACTIVE
    encapsulation = ietf, vlink = 13
```

注意这里无**broadcast**字段。

手动定义R1与R2相互为RIP邻居，使用单播相互交换路由信息。

```
[R1]rip
[R1-rip-1]peer 10.0.12.2
```

```
[R2]rip
[R2-rip-1]peer 10.0.12.1
```

配置完成后，在R2上查看路由信息。

```
[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 16      Routes : 16

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.1.0/24  RIP     100  1           D   10.0.12.1       Serial1/0/0
      10.0.2.0/24  Direct  0    0           D   10.0.2.2        LoopBack0
      10.0.2.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.2.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.12.0/24  Direct  0    0           D   10.0.12.2       Serial1/0/0
     10.0.12.1/32  Direct  0    0           D   10.0.12.1       Serial1/0/0
     10.0.12.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
   10.0.12.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.23.0/24  Direct  0    0           D   10.0.23.2       Serial2/0/0
     10.0.23.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.23.3/32  Direct  0    0           D   10.0.23.3       Serial2/0/0
   10.0.23.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

使用**ping**命令进行连通性测试。

```
[R2]ping 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=255 time=35 ms
    Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=255 time=41 ms
    Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=255 time=31 ms
    Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=255 time=41 ms
    Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=255 time=41 ms

  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
```

```
0.00% packet loss
round-trip min/avg/max = 31/37/41 ms
```

注意：有RIPv2协议默认进行网络汇总，所以在R1设备上查看路由信息时，仅有一条RIP路由。

步骤五. 配置 R2 与 R3 之间运行 OSPF，手动定义邻居关系

```
[R2]router id 10.0.2.2
[R2]ospf 1
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0]network 10.0.0.0 0.255.255.255

[R3]router id 10.0.3.3
[R3]ospf 1
[R3-ospf-1]area 0
[R3-ospf-1-area-0.0.0.0]network 10.0.0.0 0.255.255.255
```

配置完成后，以R3为例查看路由信息。

```
[R3]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 11      Routes : 11

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.3.0/24  Direct  0    0           D   10.0.3.3        LoopBack0
      10.0.3.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.3.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.23.0/24  Direct  0    0           D   10.0.23.3       Serial2/0/0
     10.0.23.2/32  Direct  0    0           D   10.0.23.2       Serial2/0/0
     10.0.23.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
   10.0.23.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

注意这里没有学习到R2发送过来的路由信息。

默认情况下，OSPF认为封装为帧中继的接口网络模式为“NBMA”，默认

不主动发现邻居。

```
[R3]display ospf interface Serial 2/0/0

        OSPF Process 1 with Router ID 10.0.3.3
                Interfaces


 Interface: 10.0.23.3 (Serial2/0/0)
 Cost: 1562    State: Waiting    Type: NBMA     MTU: 1500
 Priority: 1
 Designated Router: 0.0.0.0
 Backup Designated Router: 0.0.0.0
 Timers: Hello 30 , Dead 120 , Poll  120 , Retransmit 5 , Transmit Delay 1
```

以R3为例，查看OSPF建立的邻居关系。

```
[R3]display ospf peer

        OSPF Process 1 with Router ID 10.0.3.3
```

在这种情况下，未能自动发现邻居关系，必须手动定义邻居关系。

```
[R2]ospf 1
[R2-ospf-1]peer 10.0.23.3

[R3]ospf 1
[R3-ospf-1]peer 10.0.23.2
```

配置完成后查看R3的OSPF邻居关系。

```
[R3]disp ospf peer

        OSPF Process 1 with Router ID 10.0.3.3
                Neighbors

 Area 0.0.0.0 interface 10.0.23.3(Serial2/0/0)'s neighbors
 Router ID: 10.0.2.2        Address: 10.0.23.2
   State: Full  Mode:Nbr is  Slave  Priority: 1
   DR: 10.0.23.2  BDR: None   MTU: 0
   Dead timer due in 116 sec
   Retrans timer interval: 5
   Neighbor is up for 00:00:04
   Authentication Sequence: [ 0 ]
```

此时邻居关系已经建立。

以R3为例，查看路由表信息。

```
[R3]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 13      Routes : 13

Destination/Mask    Proto   Pre  Cost      Flags NextHop        Interface

      10.0.2.2/32  OSPF    10   1562        D   10.0.23.2       Serial2/0/0
      10.0.3.0/24  Direct  0    0           D   10.0.3.3        LoopBack0
      10.0.3.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.3.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     10.0.12.0/24  OSPF    10   3124        D   10.0.23.2       Serial2/0/0
     10.0.23.0/24  Direct  0    0           D   10.0.23.3       Serial2/0/0
     10.0.23.2/32  Direct  0    0           D   10.0.23.2       Serial2/0/0
     10.0.23.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
   10.0.23.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

测试R3与R2的连通性。

```
[R3]ping 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.2.2: bytes=56 Sequence=1 ttl=255 time=32 ms
    Reply from 10.0.2.2: bytes=56 Sequence=2 ttl=255 time=27 ms
    Reply from 10.0.2.2: bytes=56 Sequence=3 ttl=255 time=27 ms
    Reply from 10.0.2.2: bytes=56 Sequence=4 ttl=255 time=27 ms
    Reply from 10.0.2.2: bytes=56 Sequence=5 ttl=255 time=27 ms

  --- 10.0.2.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 27/28/32 ms
```

步骤六. 配置 R2 与 R3 之间运行 OSPF，不定义邻居关系，修改网络类型为广播

在帧中继网络上运行OSPF，可以手动定义邻居，也可以在支持广播的网络上定义OSPF自动发现邻居的功能。

删除任务5中R2与R3关于手动邻居关系的定义。

```
[R2]ospf 1
[R2-ospf-1]undo peer 10.0.23.3

[R3]ospf 1
[R3-ospf-1]undo peer 10.0.23.2
```

确认帧中继接口支持广播功能。

```
[R3]display fr map-info interface Serial 2/0/0
Map Statistics for interface Serial2/0/0 (DCE)
  DLCI = 203, IP INARP 10.0.23.2, Serial2/0/0
    create time = 2011/10/11 15:02:21, status = ACTIVE
    encapsulation = ietf, vlink = 2, broadcast
```

确认广播功能后，确认接口的OSPF网络类型。

```
[R3]display ospf interface Serial 2/0/0

        OSPF Process 1 with Router ID 10.0.3.3
                Interfaces



 Interface: 10.0.23.3 (Serial2/0/0)
 Cost: 1562    State: DR       Type: NBMA     MTU: 1500
 Priority: 1
 Designated Router: 10.0.23.3
 Backup Designated Router: 10.0.23.2
 Timers: Hello 30 , Dead 120 , Poll  120 , Retransmit 5 , Transmit Delay 1
```

修改该网络类型为广播。

```
[R2]interface Serial 2/0/0
[R2-Serial2/0/0]ospf network-type broadcast

[R3]interface Serial 2/0/0
[R3-Serial2/0/0]ospf network-type broadcast
```

完成后关闭R3的S2/0/0接口，然后再打开，以便刷新邻居关系。

```
[R3-Serial2/0/0]shutdown
[R3-Serial2/0/0]undo shutdown
```

配置完成后，稍等片刻，待OSPF邻居关系建立后，查看OSPF邻居关系。

```
[R3]display ospf peer

        OSPF Process 1 with Router ID 10.0.3.3
                Neighbors

 Area 0.0.0.0 interface 10.0.23.3(Serial2/0/0)'s neighbors
 Router ID: 10.0.2.2        Address: 10.0.23.2
   State: Full  Mode:Nbr is  Slave  Priority: 1
   DR: 10.0.23.3  BDR: 10.0.23.2  MTU: 0
   Dead timer due in 34  sec
   Retrans timer interval: 4
   Neighbor is up for 00:00:20
   Authentication Sequence: [ 0 ]
```

以R3为例，参看路由信息，并测试R3与R2的连通性。

```
[R3]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 13      Routes : 13

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

      10.0.2.2/32  OSPF    10   1562        D   10.0.23.2      Serial2/0/0
      10.0.3.0/24  Direct  0    0           D   10.0.3.3       LoopBack0
      10.0.3.3/32  Direct  0    0           D   127.0.0.1      InLoopBack0
    10.0.3.255/32  Direct  0    0           D   127.0.0.1      InLoopBack0
     10.0.12.0/24  OSPF    10   3124        D   10.0.23.2      Serial2/0/0
     10.0.23.0/24  Direct  0    0           D   10.0.23.3      Serial2/0/0
     10.0.23.2/32  Direct  0    0           D   10.0.23.2      Serial2/0/0
     10.0.23.3/32  Direct  0    0           D   127.0.0.1      InLoopBack0
   10.0.23.255/32  Direct  0    0           D   127.0.0.1      InLoopBack0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1      InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1      InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1      InLoopBack0
```

```
[R3]display ospf interface Serial 2/0/0

        OSPF Process 1 with Router ID 10.0.3.3
               Interfaces


 Interface: 10.0.23.3 (Serial2/0/0)
 Cost: 1562    State: DR       Type: Broadcast    MTU: 1500
 Priority: 1
 Designated Router: 10.0.23.3
 Backup Designated Router: 10.0.23.2
 Timers: Hello 10 , Dead 40 , Poll  120 , Retransmit 5 , Transmit Delay 1
[R3]ping 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.2.2: bytes=56 Sequence=1 ttl=255 time=35 ms
    Reply from 10.0.2.2: bytes=56 Sequence=2 ttl=255 time=30 ms
    Reply from 10.0.2.2: bytes=56 Sequence=3 ttl=255 time=30 ms
    Reply from 10.0.2.2: bytes=56 Sequence=4 ttl=255 time=30 ms
    Reply from 10.0.2.2: bytes=56 Sequence=5 ttl=255 time=30 ms

  --- 10.0.2.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 30/31/35 ms
```

附加实验：思考并验证

思考帧中继接口的广播功能是以怎样的形式体现的？有条件的情况下，进行验证。

最终设备配置

```
[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
```

```
#
interface Serial1/0/0
 link-protocol fr
 fr interface-type dce
 undo fr inarp
 fr dlci 102
 fr map ip 10.0.12.2 102
 ip address 10.0.12.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
rip 1
 undo summary
 version 2
 peer 10.0.12.2
 network 10.0.0.0
#
return

[R2]display current-configuration
[V200R001C01SPC300]
#
 sysname R2
#
 router id 10.0.2.2
#
interface Serial1/0/0
 link-protocol fr
 fr dlci 102
 undo fr inarp
 fr map ip 10.0.12.1 102
 ip address 10.0.12.2 255.255.255.0
#
interface Serial2/0/0
 link-protocol fr
 ip address 10.0.23.2 255.255.255.0
 ospf network-type broadcast
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
ospf 1
```

```
 area 0.0.0.0
  network 10.0.0.0 0.255.255.255
#
rip 1
 undo summary
 version 2
 peer 10.0.12.1
 network 10.0.0.0
#
return

[R3]display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
router id 10.0.3.3
#
interface Serial2/0/0
 link-protocol fr
 fr interface-type dce
 fr dlci 203
 ip address 10.0.23.3 255.255.255.0
 ospf network-type broadcast
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
ospf 1
 area 0.0.0.0
  network 10.0.0.0 0.255.255.255
#
return
```

实验 8-3 帧中继（FR 交换机环境）配置

学习目的

- 掌握在存在Frame Relay交换机的情况下，配置FR路由器接口的方法
- 掌握在Hub-and-spoke模式下，RIP的配置方法
- 掌握在Hub-and-spoke模式下，OSPF的配置方法
- 掌握OSPF在配置成Point-to-multipoint模式下的FR接口的配置方法

拓扑图

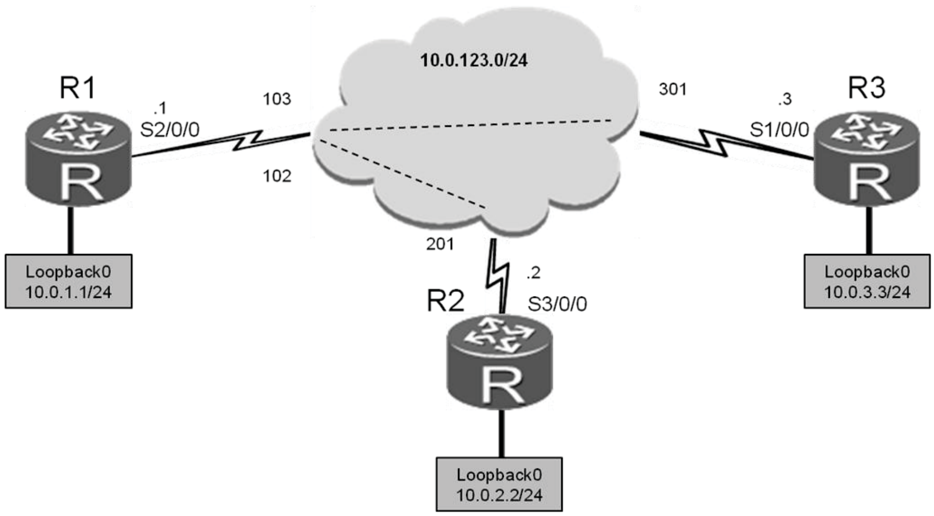


图8.3 帧中继（FR交换机环境）配置实验拓扑图

场景

你是你们公司的网络管理员。公司的总部有一台路由器R1，R2和R3分别是其他两个分部的路由器。现在你需要将总部和分部进行互联。广域网链路上使用帧中继方式进行网络互联，Hub-and-spoke模式。

学习任务

步骤一. 基本配置与 IP 编址

配置地址等信息。在配置帧中继封装时，需要关闭Inarp功能，手动定义PVC的DLCI号码与IP地址的映射关系。

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface Serial 2/0/0
[R1-Serial2/0/0]link-protocol fr
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R1-Serial2/0/0]ip address 10.0.123.1 24
[R1-Serial2/0/0]undo fr inarp
[R1-Serial2/0/0]fr map ip 10.0.123.2 102 broadcast
[R1-Serial2/0/0]fr map ip 10.0.123.3 103 broadcast
[R1-Serial2/0/0]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface Serial 3/0/0
[R2-Serial3/0/0]link-protocol fr
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R2-Serial3/0/0]ip address 10.0.123.2 24
[R2-Serial3/0/0]undo fr inarp
[R2-Serial3/0/0]fr map ip 10.0.123.1 201 broadcast
[R2-Serial3/0/0]interface loopback 0
[R2-LoopBack0]ip address 10.0.2.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface Serial 1/0/0
[R3-Serial1/0/0]link-protocol fr
Warning: The encapsulation protocol of the link will be changed. Continue? [Y/N]:y
[R3-Serial1/0/0]ip address 10.0.123.3 24
[R3-Serial1/0/0]undo fr inarp
[R3-Serial1/0/0]fr map ip 10.0.123.1 301 broadcast
[R3-Serial1/0/0]interface loopback 0
```

```
[R3-LoopBack0]ip address 10.0.3.3 24
```

完成后测试网络的连通性。

```
[R1]ping 10.0.123.2
  PING 10.0.123.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.123.2: bytes=56 Sequence=1 ttl=255 time=64 ms
    Reply from 10.0.123.2: bytes=56 Sequence=2 ttl=255 time=59 ms
    Reply from 10.0.123.2: bytes=56 Sequence=3 ttl=255 time=59 ms
    Reply from 10.0.123.2: bytes=56 Sequence=4 ttl=255 time=59 ms
    Reply from 10.0.123.2: bytes=56 Sequence=5 ttl=255 time=59 ms

  --- 10.0.123.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 59/60/64 ms

[R1]ping 10.0.123.3
  PING 10.0.123.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.123.3: bytes=56 Sequence=1 ttl=255 time=64 ms
    Reply from 10.0.123.3: bytes=56 Sequence=2 ttl=255 time=59 ms
    Reply from 10.0.123.3: bytes=56 Sequence=3 ttl=255 time=59 ms
    Reply from 10.0.123.3: bytes=56 Sequence=4 ttl=255 time=59 ms
    Reply from 10.0.123.3: bytes=56 Sequence=5 ttl=255 time=59 ms

  --- 10.0.123.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 59/60/64 ms
```

查看R1接口帧中继封装信息。

```
[R1]display fr interface Serial 2/0/0
Serial2/0/0, DTE, physical up, protocol up

[R1]display fr map-info interface Serial 2/0/0
Map Statistics for interface Serial2/0/0 (DTE)
  DLCI = 102, IP 10.0.123.2, Serial2/0/0
    create time = 2011/11/16 09:28:49, status = ACTIVE
    encapsulation = ietf, vlink = 1, broadcast
  DLCI = 103, IP 10.0.123.3, Serial2/0/0
    create time = 2011/11/16 09:28:56, status = ACTIVE
```

```
encapsulation = ietf, vlink = 2, broadcast
```

步骤二. 配置 R1、R2、和 R3 之间运行 RIPv2

配置RIP协议，使用Version 2，所有网段都在RIP区域。默认配置，不定义静态邻居。另外需要关闭自动汇总。同时需要注意的是，由于帧中继网络的特殊性，默认情况下，帧中继接口RIP的水平分割功能被关闭。实验中，不对水平分割进行修改。

```
[R1]rip 1
[R1-rip-1]version 2
[R1-rip-1]network 10.0.0.0
[R1-rip-1]undo summary

[R2]rip 1
[R2-rip-1]version 2
[R2-rip-1]network 10.0.0.0
[R2-rip-1]undo summary

[R3]rip 1
[R3-rip-1]version 2
[R3-rip-1]network 10.0.0.0
[R3-rip-1]undo summary
```

在R1、R2、R3上分别查看路由表，确认路由信息学习的结果。

```
[R1]display ip routing-table protocol rip
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : RIP
       Destinations : 2       Routes : 2

RIP routing table status : <Active>
       Destinations : 2       Routes : 2

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface


      10.0.2.0/24  RIP    100  1          D   10.0.123.2     Serial2/0/0
      10.0.3.0/24  RIP    100  1          D   10.0.123.3     Serial2/0/0

RIP routing table status : <Inactive>
       Destinations : 0       Routes : 0
```

```
[R2]display ip routing-table protocol rip
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : RIP
       Destinations : 2      Routes : 2

RIP routing table status : <Active>
       Destinations : 2      Routes : 2

Destination/Mask   Proto  Pre  Cost     Flags NextHop       Interface

      10.0.1.0/24  RIP    100  1         D   10.0.123.1     Serial3/0/0
      10.0.3.0/24  RIP    100  2         D   10.0.123.1     Serial3/0/0

RIP routing table status : <Inactive>
       Destinations : 0      Routes : 0

[R3]display ip routing-table protocol rip
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Public routing table : RIP
       Destinations : 2      Routes : 2

RIP routing table status : <Active>
       Destinations : 2      Routes : 2

Destination/Mask   Proto  Pre  Cost     Flags NextHop       Interface

      10.0.1.0/24  RIP    100  1         D   10.0.123.1     Serial1/0/0
      10.0.2.0/24  RIP    100  2         D   10.0.123.1     Serial1/0/0

RIP routing table status : <Inactive>
       Destinations : 0      Routes : 0
```

在R3上连通性测试。

```
[R3]ping 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=255 time=68 ms
    Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=255 time=63 ms
    Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=255 time=63 ms
    Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=255 time=63 ms
    Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=255 time=63 ms
```

```
  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 63/64/68 ms

[R3]ping 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.2.2 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss
```

查看路由，确定R3不能与R2通讯的原因。

以下简述进行此次故障排除的思路：

- 观察R3路由表，查看是否有到达10.0.2.2地址的路由（有路由）；
- 查看该路由下一跳是哪个IP地址，该地址R3是否可达，是否存在对应的三层IP地址和二层PVC的对应关系（可达，存在对应关系）；
- 查看沿路设备，是否有到达10.0.2.2地址的路由以及路由得下一跳是否可达，是否存在三层IP地址和二层PVC的对应关系（可达，存在对应关系）；
- 查看目标设备，是否有到达回应的数据包目标地址的路由，以及下一跳是否可达（不可达，回应数据包的目标地址是10.0.123.3，R2上存在到达该地址的路由，但是不存在对应的三层IP地址和二层PVC的对应关系）

下面给出对应的输出信息。

```
[R3]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 13      Routes : 13

Destination/Mask    Proto   Pre  Cost      Flags NextHop        Interface

      10.0.1.0/24  RIP     100  1           D   10.0.123.1      Serial1/0/0
      10.0.2.0/24  RIP     100  2           D   10.0.123.1      Serial1/0/0
```

```
     10.0.3.0/24  Direct  0    0          D   10.0.3.3        LoopBack0
     10.0.3.3/32  Direct  0    0          D   127.0.0.1       InLoopBack0
   10.0.3.255/32  Direct  0    0          D   127.0.0.1       InLoopBack0
   10.0.123.0/24  Direct  0    0          D   10.0.123.3      Serial1/0/0
   10.0.123.1/32  Direct  0    0          D   10.0.123.1      Serial1/0/0
   10.0.123.3/32  Direct  0    0          D   127.0.0.1       InLoopBack0
 10.0.123.255/32  Direct  0    0          D   127.0.0.1       InLoopBack0
      127.0.0.0/8   Direct  0    0          D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0          D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0          D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0          D   127.0.0.1       InLoopBack0

[R3]display fr map-info interface Serial 1/0/0
Map Statistics for interface Serial1/0/0 (DTE)
  DLCI = 301, IP 10.0.123.1, Serial1/0/0
    create time = 2011/11/16 09:22:30, status = ACTIVE
    encapsulation = ietf, vlink = 1, broadcast

[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 14       Routes : 14

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

     10.0.1.0/24  Direct  0    0          D   10.0.1.1        LoopBack0
     10.0.1.1/32  Direct  0    0          D   127.0.0.1       InLoopBack0
   10.0.1.255/32  Direct  0    0          D   127.0.0.1       InLoopBack0
     10.0.2.0/24  RIP     100  1          D   10.0.123.2      Serial2/0/0
     10.0.3.0/24  RIP     100  1          D   10.0.123.3      Serial2/0/0
   10.0.123.0/24  Direct  0    0          D   10.0.123.1      Serial2/0/0
   10.0.123.1/32  Direct  0    0          D   127.0.0.1       InLoopBack0
   10.0.123.2/32  Direct  0    0          D   10.0.123.2      Serial2/0/0
   10.0.123.3/32  Direct  0    0          D   10.0.123.3      Serial2/0/0
 10.0.123.255/32  Direct  0    0          D   127.0.0.1       InLoopBack0
      127.0.0.0/8   Direct  0    0          D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0          D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0          D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0          D   127.0.0.1       InLoopBack0

[R1]display fr map-info interface Serial 2/0/0
Map Statistics for interface Serial2/0/0 (DTE)
```

```
  DLCI = 102, IP 10.0.123.2, Serial2/0/0
    create time = 2011/11/16 09:28:49, status = ACTIVE
    encapsulation = ietf, vlink = 1, broadcast
  DLCI = 103, IP 10.0.123.3, Serial2/0/0
    create time = 2011/11/16 09:28:56, status = ACTIVE
    encapsulation = ietf, vlink = 2, broadcast

[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
         Destinations : 13      Routes : 13

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

       10.0.1.0/24  RIP     100  1          D   10.0.123.1     Serial3/0/0
       10.0.2.0/24  Direct  0    0          D   10.0.2.2       LoopBack0
       10.0.2.2/32  Direct  0    0          D   127.0.0.1      InLoopBack0
     10.0.2.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
       10.0.3.0/24  RIP     100  2          D   10.0.123.1     Serial3/0/0
     10.0.123.0/24  Direct  0    0          D   10.0.123.2     Serial3/0/0
     10.0.123.1/32  Direct  0    0          D   10.0.123.1     Serial3/0/0
     10.0.123.2/32  Direct  0    0          D   127.0.0.1      InLoopBack0
   10.0.123.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
        127.0.0.0/8 Direct  0    0          D   127.0.0.1      InLoopBack0
       127.0.0.1/32 Direct  0    0          D   127.0.0.1      InLoopBack0
127.255.255.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
255.255.255.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0

[R2]display fr map-info interface Serial 3/0/0
Map Statistics for interface Serial3/0/0 (DTE)
  DLCI = 201, IP 10.0.123.1, Serial3/0/0
    create time = 2011/11/16 09:21:10, status = ACTIVE
    encapsulation = ietf, vlink = 1, broadcast
```

注意关键点是R2没有达到10.0.123.3的PVC。

步骤三. 调整网络参数，实现 R2 和 R3 的连通性

故障定位在R2和R3的帧中继接口之间缺少虚电路。我们可以配置IP地址和PVC的对应关系，使R2和R3帧中继接口之间的通讯通过R1来实现。

```
[R2]interface Serial 3/0/0
[R2-Serial3/0/0]fr map ip 10.0.123.3 201 broadcast

[R3]interface Serial 1/0/0
[R3-Serial1/0/0]fr map ip 10.0.123.2 301 broadcast
```

完成后查看R2和R3上IP与PVC的映射关系表，并测试网络连通性。

```
[R3]display fr map-info interface Serial 1/0/0
Map Statistics for interface Serial1/0/0 (DTE)
  DLCI = 301, IP 10.0.123.1, Serial1/0/0
    create time = 2011/11/16 09:22:30, status = ACTIVE
    encapsulation = ietf, vlink = 1, broadcast
  DLCI = 301, IP 10.0.123.2, Serial1/0/0
    create time = 2011/11/16 09:55:23, status = ACTIVE
    encapsulation = ietf, vlink = 2, broadcast

[R3]ping 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.2.2: bytes=56 Sequence=1 ttl=254 time=118 ms
    Reply from 10.0.2.2: bytes=56 Sequence=2 ttl=254 time=123 ms
    Reply from 10.0.2.2: bytes=56 Sequence=3 ttl=254 time=123 ms
    Reply from 10.0.2.2: bytes=56 Sequence=4 ttl=254 time=123 ms
    Reply from 10.0.2.2: bytes=56 Sequence=5 ttl=254 time=123 ms

  --- 10.0.2.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 118/122/123 ms
```

步骤四. 配置 R1 与 R2 之间运行 OSPF

删除RIP的配置，删除R2和R3在步骤三建立的IP与PVC的映射关系。

```
[R1]undo rip 1
Warning: The RIP process will be deleted. Continue?[Y/N]y
[R1]

[R2]interface Serial 3/0/0
[R2-Serial3/0/0]undo fr map ip 10.0.123.3 201
[R2-Serial3/0/0]quit
[R2]undo rip 1
```

```
Warning: The RIP process will be deleted. Continue?[Y/N]y
[R2]

[R3]interface Serial 1/0/0
[R3-Serial1/0/0]undo fr map ip 10.0.123.2 301
[R3-Serial1/0/0]quit
[R3]undo rip 1
Warning: The RIP process will be deleted. Continue?[Y/N]y
[R3]
```

在R1、R2和R3上配置单区域OSPF。

```
[R1]ospf 1 router-id 10.0.1.1
[R1-ospf-1]area 0
[R1-ospf-1-area-0.0.0.0]network 10.0.0.0 0.255.255.255

[R2]ospf 1 router-id 10.0.2.2
[R2-ospf-1]area 0
[R2-ospf-1-area-0.0.0.0]network 10.0.0.0 0.255.255.255

[R3]ospf 1 router-id 10.0.3.3
[R3-ospf-1]area 0
[R3-ospf-1-area-0.0.0.0]network 10.0.0.0 0.255.255.255
```

基本配置完成后，OSPF无法建立邻居关系，原因是OSPF认为帧中继网络默认识NBMA网络，不支持广播，不自动发现邻居。

```
[R3]display ospf interface Serial 1/0/0 verbose

        OSPF Process 1 with Router ID 10.0.3.3
               Interfaces


 Interface: 10.0.123.3 (Serial1/0/0)
 Cost: 1562    State: DR       Type: NBMA     MTU: 1500
 Priority: 1
 Designated Router: 10.0.123.3
 Backup Designated Router: 0.0.0.0
 Timers: Hello 30 , Dead 120 , Poll  120 , Retransmit 5 , Transmit Delay 1
  IO Statistics
          Type        Input     Output
          Hello           0          0
   DB Description          0          0
   Link-State Req          0          0
```

```
Link-State Update          0        0
  Link-State Ack          0        0
 OpaqueId: 0   PrevState: Waiting
```

对于帧中继网络上运行OSPF，有多种解决方法，本次实验中介绍将接口的OSPF网络类型定义为Point-to-multipoint的方法来实现。

步骤五. 配置接口的 OSPF 网络类型为 Point-to-multipoint

```
[R1]interface Serial 2/0/0
[R1-Serial2/0/0]ospf network-type p2mp

[R2]interface Serial 3/0/0
[R2-Serial3/0/0]ospf network-type p2mp

[R3]interface Serial 1/0/0
[R3-Serial1/0/0]ospf network-type p2mp
```

配置完成后，稍等片刻，待邻居关系建立。查看邻居关系及路由信息。

```
[R1]display ospf peer brief

       OSPF Process 1 with Router ID 10.0.1.1
              Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id         Interface                     Neighbor id     State
 0.0.0.0         Serial2/0/0                    10.0.2.2       Full
 0.0.0.0         Serial2/0/0                    10.0.3.3       Full
 ----------------------------------------------------------------------------

[R1]display ip routing-table
Route Flags: R - relay, D - download to fib
----------------------------------------------------------------------------
Routing Tables: Public
       Destinations : 14      Routes : 14

Destination/Mask    Proto   Pre  Cost     Flags NextHop        Interface

     10.0.1.0/24  Direct  0    0          D   10.0.1.1       LoopBack0
     10.0.1.1/32  Direct  0    0          D   127.0.0.1      InLoopBack0
   10.0.1.255/32  Direct  0    0          D   127.0.0.1      InLoopBack0
     10.0.2.2/32  OSPF    10   1562       D   10.0.123.2     Serial2/0/0
     10.0.3.3/32  OSPF    10   1562       D   10.0.123.3     Serial2/0/0
```

```
    10.0.123.0/24  Direct  0    0           D   10.0.123.1      Serial2/0/0
    10.0.123.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.123.2/32  Direct  0    0           D   10.0.123.2      Serial2/0/0
    10.0.123.3/32  Direct  0    0           D   10.0.123.3      Serial2/0/0
  10.0.123.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.0/8  Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0

[R2]display ospf peer brief

        OSPF Process 1 with Router ID 10.0.2.2
                Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id          Interface                      Neighbor id      State
 0.0.0.0          Serial3/0/0                     10.0.1.1        Full
 ----------------------------------------------------------------------------

[R2]display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 14       Routes : 14

Destination/Mask    Proto   Pre  Cost      Flags NextHop         Interface

      10.0.1.1/32  OSPF    10   1562        D   10.0.123.1      Serial3/0/0
      10.0.2.0/24  Direct  0    0           D   10.0.2.2        LoopBack0
      10.0.2.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.2.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      10.0.3.3/32  OSPF    10   3124        D   10.0.123.1      Serial3/0/0
    10.0.123.0/24  Direct  0    0           D   10.0.123.2      Serial3/0/0
    10.0.123.1/32  Direct  0    0           D   10.0.123.1      Serial3/0/0
    10.0.123.2/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.123.3/32  OSPF    10   3124        D   10.0.123.1      Serial3/0/0
  10.0.123.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
      127.0.0.0/8  Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0

[R3]display ospf peer brief
```

```
        OSPF Process 1 with Router ID 10.0.3.3
                Peer Statistic Information
 ----------------------------------------------------------------------------
 Area Id          Interface                     Neighbor id      State
 0.0.0.0          Serial1/0/0                    10.0.1.1        Full
 ----------------------------------------------------------------------------

[R3]display ip routing-table
Route Flags: R - relay, D - download to fib
----------------------------------------------------------------------------
Routing Tables: Public
        Destinations : 14      Routes : 14

Destination/Mask    Proto  Pre  Cost      Flags NextHop         Interface

      10.0.1.1/32  OSPF    10   1562        D   10.0.123.1      Serial1/0/0
      10.0.2.2/32  OSPF    10   3124        D   10.0.123.1      Serial1/0/0
      10.0.3.0/24  Direct  0    0           D   10.0.3.3        LoopBack0
      10.0.3.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.3.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
    10.0.123.0/24  Direct  0    0           D   10.0.123.3      Serial1/0/0
    10.0.123.1/32  Direct  0    0           D   10.0.123.1      Serial1/0/0
    10.0.123.2/32  OSPF    10   3124        D   10.0.123.1      Serial1/0/0
    10.0.123.3/32  Direct  0    0           D   127.0.0.1       InLoopBack0
  10.0.123.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.0/8   Direct  0    0           D   127.0.0.1       InLoopBack0
     127.0.0.1/32  Direct  0    0           D   127.0.0.1       InLoopBack0
127.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
255.255.255.255/32  Direct  0    0           D   127.0.0.1       InLoopBack0
```

在R3上测试网络连通性。

```
[R3]ping 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=255 time=55 ms
    Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=255 time=60 ms
    Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=255 time=61 ms
    Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=255 time=61 ms
    Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=255 time=61 ms

  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
```

```
    0.00% packet loss
    round-trip min/avg/max = 55/59/61 ms

[R3]ping 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.2.2: bytes=56 Sequence=1 ttl=254 time=116 ms
    Reply from 10.0.2.2: bytes=56 Sequence=2 ttl=254 time=121 ms
    Reply from 10.0.2.2: bytes=56 Sequence=3 ttl=254 time=121 ms
    Reply from 10.0.2.2: bytes=56 Sequence=4 ttl=254 time=120 ms
    Reply from 10.0.2.2: bytes=56 Sequence=5 ttl=254 time=120 ms

  --- 10.0.2.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 116/119/121 ms

[R3]ping 10.0.123.2
  PING 10.0.123.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.123.2: bytes=56 Sequence=1 ttl=254 time=115 ms
    Reply from 10.0.123.2: bytes=56 Sequence=2 ttl=254 time=119 ms
    Reply from 10.0.123.2: bytes=56 Sequence=3 ttl=254 time=119 ms
    Reply from 10.0.123.2: bytes=56 Sequence=4 ttl=254 time=119 ms
    Reply from 10.0.123.2: bytes=56 Sequence=5 ttl=254 time=119 ms

  --- 10.0.123.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 115/118/119 ms
```

附加实验：思考并验证

在步骤四中，提到有多种方式来实现OSPF在帧中继网络上正常工作。我们采用了将网络类型修改，来实现了互通的方式。

思考，OSPF默认认为帧中继网络不支持广播，不主动发现邻居。是否可以手动定义邻居，从这个角度思考如何实现OSPF网络的连通性。

分析为什么步骤五没有手动建立R2和R3之间的IP地址与PVC的对应关系，但是仍然可以实现相互通讯的原因。

最终设备配置

```
[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
interface Serial2/0/0
 link-protocol fr
 undo fr inarp
 fr map ip 10.0.123.2 102 broadcast
 fr map ip 10.0.123.3 103 broadcast
 ip address 10.0.123.1 255.255.255.0
 ospf network-type p2mp
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
ospf 1 router-id 10.0.1.1
 area 0.0.0.0
  network 10.0.0.0 0.255.255.255
#
return

[R2]display current-configuration
[V200R001C01SPC300]
#
 sysname R2
#
interface Serial3/0/0
 link-protocol fr
 undo fr inarp
 fr map ip 10.0.123.1 201 broadcast
 ip address 10.0.123.2 255.255.255.0
 ospf network-type p2mp
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
ospf 1 router-id 10.0.2.2
 area 0.0.0.0
```

```
  network 10.0.0.0 0.255.255.255
#
return

[R3]display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
interface Serial1/0/0
 link-protocol fr
 undo fr inarp
 fr map ip 10.0.123.1 301 broadcast
 ip address 10.0.123.3 255.255.255.0
 ospf network-type p2mp
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
ospf 1 router-id 10.0.3.3
 area 0.0.0.0
  network 10.0.0.0 0.255.255.255
#
return
```

第九章 防火墙技术

实验 9-1 USG 防火墙基本配置

学习目的

- 掌握登陆USG防火墙的方法
- 掌握修改防火墙设备名的方法
- 掌握对防火墙的时间、时区进行修改的方法
- 掌握修改防火墙登陆标语信息的方法
- 掌握修改防火墙登陆密码的方法
- 掌握查看、保存和删除防火墙配置的方法
- 掌握在防火墙上配置VLAN、接口地址、测试基本连通性的方法
- 掌握重启防火墙的方法

拓扑图

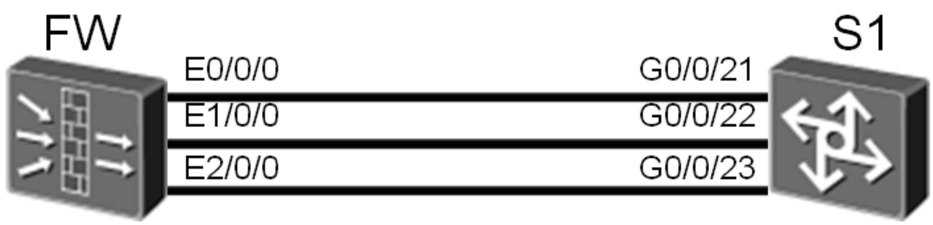


图9.1 USG防火墙基本配置

场景

你是你们公司的网络管理员。公司刚购买了一台USG2160防火墙，准备连接到核心交换机S1上，并实现不同VLAN之间数据包传输时的过滤。现在你需要

熟悉防火墙的各种基本操作。

学习任务

步骤一. 登陆缺省配置的防火墙并修改防火墙的名称

防火墙与路由器一样，有一个Console接口，使用Console线缆将Console接口和计算机的COM口连接在一块，使用Windows操作系统自带的超级终端软件，即可连接到防火墙。具体的操作步骤参考”实验1-1 VRP平台基本操作 “。

防火墙的缺省配置中，包括了用户名和密码，其中用户名为”admin “，密码为”Admin@123 “，所以登陆时需输入用户名和密码信息，输入时注意区分大小写。

```
*************************************************************************
*     Copyright(C) 2008-2012 Huawei Technologies Co., Ltd.             *
*                     All rights reserved                               *
*            Without the owner's prior written consent,                 *
*       no decompiling or reverse-engineering shall be allowed.        *
*************************************************************************

User interface con0 is available

Please Press ENTER.

Login authentication

Username:admin
Password:*********
NOTICE:This is a private communication system.
      Unauthorized access or use may lead to prosecution.
Warning: Using default authentication method and password on console.
<USG2100>
```

修改防火墙的名称的方法与修改路由器名称的方法一致。

另外需要注意的是，由于防火墙和路由器同样使用了VRP平台操作系统，所以在命令级别、命令帮助等，与路由器上相应操作相同。

```
<USG2100>system-view
Enter system view, return user view with Ctrl+Z.
[USG2100]sysname FW
```

```
[FW]
```

步骤二.　修改防火墙的时间和时区信息

默认情况下防火墙没有定义时区，系统保存的时间与实际时间可能不符。使用时应该根据实际的情况定义时间和时区信息。实验中我们将时区定义到东八区，并定义标准时间。

```
<FW>clock timezone 1 add 08:00:00
<FW>display clock
2011-11-17 18:39:48
Thursday
Time Zone : 1 add 08:00:00
<FW>clock datetime 10:36:00 2011/11/17
<FW>display clock
2011-11-17 10:36:09
Thursday
Time Zone : 1 add 08:00:00
```

步骤三.　修改防火墙的登陆标语信息

默认情况下，在登陆防火墙，登陆成功后，有如下的标语信息。

```
Please Press ENTER.

Login authentication

Username:admin
Password:*********
NOTICE:This is a private communication system.
      Unauthorized access or use may lead to prosecution.
Warning: Using default authentication method and password on console.
<FW>
```

防火墙设备以此信息警告非授权的访问。

实际使用中，管理员可以根据需要修改默认的登陆标语信息。分为登陆前提示信息和登陆成功后提示信息两种。

```
[FW]header login information ^
Info: The banner text supports 220 characters max, including the start and the
end character. If you want to enter more than this, use banner file instead.
```

```
Input banner text, and quit with the character '^':
Welcome to USG2160 ^

[FW]header shell information ^
Info: The banner text supports 220 characters max, including the start and the
end character. If you want to enter more than this, use banner file instead.
Input banner text, and quit with the character '^':
Welcome to USG2160
You are logining in system Please do not delete system config files
^
[FW]
```

配置完成后，通过退出系统，然后重新进行登陆，可以查看是否生效。

```
<FW>quit
Please Press ENTER.

Welcome to USG2160

Login authentication

Username:admin
Password:*********
Welcome to USG2160
You are logining in system Please do not delete system config files

NOTICE:This is a private communication system.
      Unauthorized access or use may lead to prosecution.
Warning: Using default authentication method and password on console.
<FW>
```

如上所示，已经生效。另外需要注意的是，默认的“NOTICE”信息一般都会存在，不会消失或被替代。

步骤四. 修改登陆防火墙的用户名和密码

防火墙默认使用的用户名为“admin “，密码为”Admin@123 “。可以根据我们的需求进行修改。实验中我们新建一个用户，级别为Level3，用户名为”user1 “，密码为”huawei@123 “。需要说明的是，默认情况下Console接口登陆仅允许用户”admin “登陆。所以需要配置Console接口登陆验证方式为”aaa “，才能确保新建的用户生效。在配置中，需要指定该配置的用户名的适用范围，本次实验中选择“terminal” ，表示适用于通过Console口登陆验证的凭据。

```
[FW]aaa
[FW-aaa]local-user user1 password cipher huawei@123
[FW-aaa]local-user user1 service-type terminal
[FW-aaa]local-user user1 level 3
[FW-aaa]quit
[FW]user-interface console 0
[FW-ui-console0]authentication-mode aaa
```

退出系统，测试新用户名和密码是否生效。

```
[FW-ui-console0]return
<FW>quit


***********************************************************************
*     Copyright(C) 2008-2011 Huawei Technologies Co., Ltd.             *
*                      All rights reserved                             *
*             Without the owner's prior written consent,               *
*       no decompiling or reverse-engineering shall be allowed.        *
***********************************************************************

User interface con0 is available

Please Press ENTER.

Welcome to USG2160

Login authentication

Username:user1
Password:**********
Welcome to USG2160
You are logining in system Please donot delete system config files

NOTICE:This is a private communication system.
      Unauthorized access or use may lead to prosecution.
<FW>
```

步骤五.　掌握查看、保存和删除配置的方法

在防火墙上使用命令可以查看运行的配置和已经保存的配置。其中使用**display current-configuration**命令查看运行配置，使用**display**

saved-configuration命令查看已经保存的配置。

```
<FW>display current-configuration
#
 sysname FW
#
 l2tp domain suffix-separator @
#
 firewall packet-filter default permit interzone local trust direction inbound
 firewall packet-filter default permit interzone local trust direction outbound
 firewall packet-filter default permit interzone local untrust direction outbound
 firewall packet-filter default permit interzone local dmz direction outbound
#
 ip df-unreachables enable
#
 firewall ipv6 session link-state check
 firewall ipv6 statistic system enable
#
 dns resolve
#
 vlan batch 1
#
 firewall statistic system enable
  ……output omit……
<FW>display saved-configuration
Error:No startup config.
<FW>
```

由于尚未进行配置的保存，所以已保存的配置为空。

保存配置，并查看已保存的配置信息。

```
<FW>save
15:05:50  2011/11/17
The current configuration will be written to the device.
Are you sure to continue?[Y/N]y
Info:Please input the file name(*.cfg,*.zip)[vrpcfg.zip]:
Now saving the current configuration to the device.................
Info:The current configuration was saved to the device successfully..
<FW>display saved-configuration
# Last configuration was changed at 2011/11/17 15:05:59 from console0
#*****BEGIN****public****#
#
 sysname FW
#
```

```
 l2tp domain suffix-separator @
#
 firewall packet-filter default permit interzone local trust direction inbound
 firewall packet-filter default permit interzone local trust direction outbound
 firewall packet-filter default permit interzone local untrust direction outbound
 firewall packet-filter default permit interzone local dmz direction outbound
#
 ip df-unreachables enable
#
 firewall ipv6 session link-state check
 firewall ipv6 statistic system enable
#
 dns resolve
#
 vlan batch 1
#
 firewall statistic system enable
  ……output omit……
```

使用**delete flash:/vrpcfg.zip**命令删除保存的配置。

```
<FW>delete flash:/vrpcfg.zip
Be Careful! Deleting the next startup config file will lose your configuration.

Delete flash:/vrpcfg.zip?[Y/N]:y
%Deleting file flash:/vrpcfg.zip...
```

步骤六.　配置 VLAN、接口地址

防火墙上，接口E0/0/0为三层接口。接口E1/0/0至E1/0/7为二层接口。二层接口无法直接配置IP地址，需要在对应当VLANif接口上配置。默认情况下，设备上存在VLAN1，并且VLANif1已经配置了地址。实验中我们创建VLAN2和VLANif2，配置地址为10.0.2.1/24，并删除VLANif1的IP地址。

```
[FW]interface Vlanif 1
[FW-Vlanif1]undo ip address
[FW]vlan 2
[FW-vlan-2]interface vlanif 2
[FW-Vlanif2]ip address 10.0.2.1 24
```

配置E1/0/0接口属于VLAN2。

```
[FW]interface Ethernet 1/0/0
```

```
[FW-Ethernet1/0/0]port access vlan 2
```

给其他接口配置IP地址，E0/0/0接口配置地址10.0.1.1/24，E2/0/0接口配置地址10.0.3.1/24。

```
[FW]interface Ethernet 0/0/0
[FW-Ethernet0/0/0]ip address 10.0.1.1 24
[FW-Ethernet0/0/0]interface Ethernet 2/0/0
[FW-Ethernet2/0/0]ip address 10.0.3.1 24
```

在交换机S1上配置接口G0/0/21属于VLAN1、G0/0/22属于VLAN2、G0/0/23属于VLAN3。VLANif1接口配置IP地址10.0.1.2/24、VLANif2接口配置IP地址10.0.2.2/24、VLANif3接口配置IP地址10.0.3.2/24。

```
<Quidway>system-view
Enter system view, return user view with Ctrl+Z.
[Quidway]sysname S1
[S1]vlan batch 2 3
[S1]interface GigabitEthernet 0/0/21
[S1-GigabitEthernet0/0/21]port link-type access
[S1-GigabitEthernet0/0/21]port default vlan 1
[S1-GigabitEthernet0/0/21]interface GigabitEthernet 0/0/22
[S1-GigabitEthernet0/0/22]port link-type access
[S1-GigabitEthernet0/0/22]port default vlan 2
[S1-GigabitEthernet0/0/22]interface GigabitEthernet 0/0/23
[S1-GigabitEthernet0/0/23]port link-type access
[S1-GigabitEthernet0/0/23]port default vlan 3
[S1-GigabitEthernet0/0/23]interface vlanif 1
[S1-Vlanif1]ip address 10.0.1.2 24
[S1-Vlanif1]interface vlanif 2
[S1-Vlanif2]ip address 10.0.2.2 24
[S1-Vlanif2]interface vlanif 3
[S1-Vlanif3]ip address 10.0.3.2 24
```

由于USG2160防火墙默认需要将接口加入到trust区域内才能通过PING测试连通性（安全策略内容后续实验会讲解），而默认情况下trust区域中仅有Ethernet1/0/0~1/0/7和Vlanif1。所以先将Vlanif 2、Ethernet 0/0/0和Ethernet 2/0/0加入到trust区域中。由于Ethernet 0/0/0默认加入到untrust区域中，所以需要先从untrust区域中将其删除，再添加进trust区域中。最后测试S1与FW三个接口的连通性。

```
[FW]firewall zone untrust
[FW-zone-untrust]undo add interface Ethernet 0/0/0
[FW-zone-untrust]quit
```

```
[FW]firewall zone trust
[FW-zone-trust]add interface Vlanif 2
[FW-zone-trust]add interface Ethernet 2/0/0
[FW-zone-trust]add interface Ethernet 0/0/0

[S1]ping 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[S1]ping 10.0.2.1
  PING 10.0.2.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.2.1: bytes=56 Sequence=1 ttl=255 time=2 ms
    Reply from 10.0.2.1: bytes=56 Sequence=2 ttl=255 time=3 ms
    Reply from 10.0.2.1: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.2.1: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.2.1: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.2.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/3 ms

[S1]ping 10.0.3.1
  PING 10.0.3.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.1: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.3.1: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.3.1: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.3.1: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.3.1: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.3.1 ping statistics ---
    5 packet(s) transmitted
```

```
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 1/1/1 ms
```

步骤七. 重启防火墙

配置完成，测试成功后，我们往往会删除配置文件，并重启，以清空配置。在设备重启时，设备会提示是否保存当前配置，此时应选择不保存。

```
<FW>reboot
Info:Reading saved configuration failed.
 System will reboot, could you want to save current configuration [Y/N]?n
 System will reboot, continue?[Y/N]:y
```

附加实验：思考并验证

思考，登陆标语信息除了用于警告之外，还可以使用在哪些方面？

最终设备配置

```
[FW]display current-configuration
#
 sysname FW
#
 firewall packet-filter default permit interzone local trust direction inbound
 firewall packet-filter default permit interzone local trust direction outbound
 firewall packet-filter default permit interzone local untrust direction outbound
 firewall packet-filter default permit interzone local dmz direction outbound
#
 dns resolve
#
 vlan batch 1 to 2
#
interface Vlanif1
#
interface Vlanif2
 ip address 10.0.2.1 255.255.255.0
#
interface Cellular5/0/0
```

```
 link-protocol ppp
#
interface Ethernet0/0/0
 ip address 10.0.1.1 255.255.255.0
#
interface Ethernet1/0/0
 portswitch
 port link-type access
 port access vlan 2
#
interface Ethernet2/0/0
 ip address 10.0.3.1 255.255.255.0
#
interface NULL0
#
firewall zone local
 set priority 100
#
firewall zone trust
 set priority 85
 add interface Ethernet0/0/0
 add interface Ethernet1/0/0
 add interface Ethernet1/0/1
 add interface Ethernet1/0/2
 add interface Ethernet1/0/3
 add interface Ethernet1/0/4
 add interface Ethernet1/0/5
 add interface Ethernet1/0/6
 add interface Ethernet1/0/7
 add interface Ethernet2/0/0
 add interface Vlanif1
 add interface Vlanif2
#
firewall zone untrust
 set priority 5
#
firewall zone dmz
 set priority 50
#
aaa
 local-user admin password cipher %$%$Ir#0"8`~3LQ#K3<xK3a)g'{r%$%$
 local-user admin service-type web terminal telnet
 local-user admin level 15
```

```
 local-user user1 password cipher %$%$P-[yN}K4yXZTL0*(IWw)m#wn%$%$
 local-user user1 service-type terminal
 local-user user1 level 3
 authentication-scheme default
 #
 header shell information "Welcome to USG2160
You are logining in system Please do not delete system config files
"
 header login information "Welcome to USG2160 "
 banner enable
#
user-interface con 0
 authentication-mode aaa
user-interface tty 2
 authentication-mode password
 modem both
user-interface vty 0 4
 authentication-mode aaa
 protocol inbound all
#
Return

[S1]display current-configuration
#
!Software Version V100R006C00SPC800
 sysname S1
#
 vlan batch 2 to 3
#
interface Vlanif1
 ip address 10.0.1.2 255.255.255.0
#
interface Vlanif2
 ip address 10.0.2.2 255.255.255.0
#
interface Vlanif3
 ip address 10.0.3.2 255.255.255.0
#
interface GigabitEthernet0/0/21
 port link-type access
#
interface GigabitEthernet0/0/22
 port link-type access
```

```
 port default vlan 2
#
interface GigabitEthernet0/0/23
 port link-type access
 port default vlan 3
#
return
```

实验 9-2 USG 防火墙区域配置

学习目的

- 掌握防火墙安全区域的配置方法
- 掌握对安全区域的参数配置
- 掌握在区域之间进行包过滤的方法

拓扑图

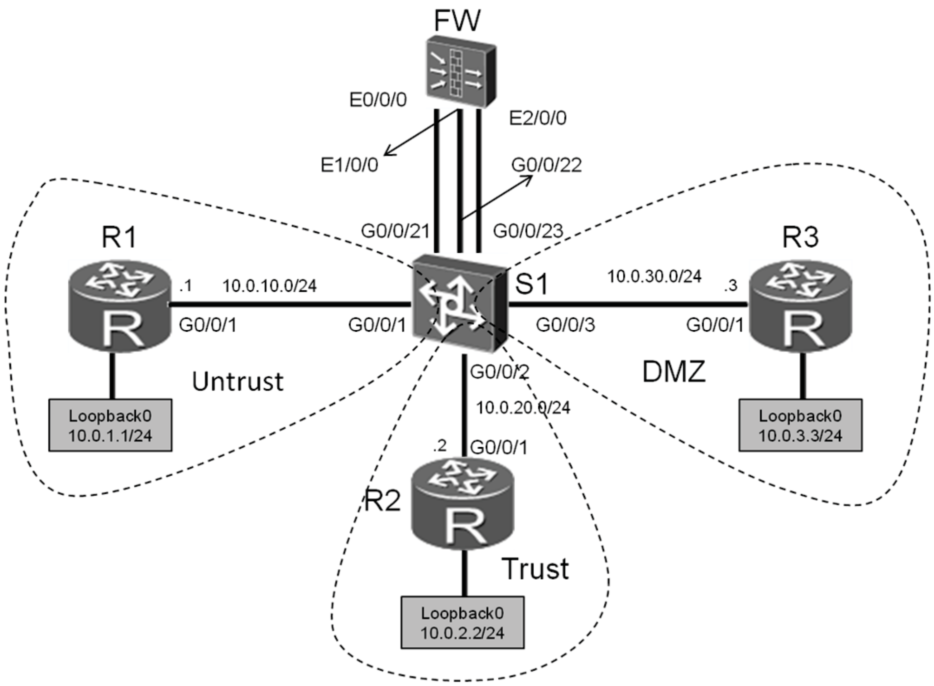


图9.3 USG防火墙区域配置

场景

你是你们公司的网络管理员。公司总部的网络分成了三个区域，包括内部区域（Trust）、外部区域（Untrust）和服务器区域（DMZ）。你设计通过防火墙来实现对数据的控制。在交换机上将G0/0/1与G0/0/21接口定义到VLAN11，

将G0/0/2与G0/0/22接口定义到VLAN12，将G0/0/3与G0/0/23接口定义到VLAN13。分别规划了三个网段。

现在满足一下工作需求：

“Trust”区域的用户可以访问“Untrust”的用户；

“Trust”和“Untrust”区域的用户可以访问“DMZ”区域的用户；

“Untrust” 区域用户不能直接访问“Trust“区域用户；

“DMZ“区域用户不能直接访问“Trust”和“Untrust”区域的用户。

学习任务

步骤一.　基本配置与 IP 编址

首先给三个路由器配置地址信息。

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.10.1 24
[R1-GigabitEthernet0/0/1]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface GigabitEthernet0/0/1
[R2-GigabitEthernet0/0/1]ip address 10.0.20.2 24
[R2-GigabitEthernet0/0/1]interface loopback 0
[R2-LoopBack0]ip address 10.0.2.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/1
[R3-GigabitEthernet0/0/1]ip address 10.0.30.3 24
[R3-GigabitEthernet0/0/1]interface loopback 0
[R3-LoopBack0]ip address 10.0.3.3 24
```

给防火墙配置地址时，需要注意Ethernet1/0/0接口为二层交换机接口，无

法配置IP地址，实验中我们在防火墙上配置VLAN12，定义Vlanif12，配置IP地址作为Inside区域的网关，使用IP地址10.0.20.254/24。另外由于默认防火墙会给它的Vlanif1接口配置地址，实验中为避免干扰，删除该配置。

```
<USG2100>system-view
Enter system view, return user view with Ctrl+Z.
[USG2100]sysname FW
[FW]vlan 12
[FW-vlan-12]quit
[FW]interface Vlanif 12
[FW-Vlanif12]ip address 10.0.20.254 24
[FW-Vlanif12]interface ethernet 1/0/0
[FW-Ethernet1/0/0]port  access vlan 12
[FW-Ethernet1/0/0]quit
[FW]interface Vlanif 1
[FW-Vlanif1]undo ip address
[FW]interface Ethernet 0/0/0
[FW-Ethernet0/0/0]ip address 10.0.10.254 24
[FW-Ethernet0/0/0]interface ethernet 2/0/0
[FW-Ethernet2/0/0]ip address 10.0.30.254 24
```

交换机上需要按照需求定义VLAN。

```
[Quidway]sysname S1
[S1]vlan batch 11 to 13
[S1]interface GigabitEthernet 0/0/1
[S1-GigabitEthernet0/0/1]port link-type access
[S1-GigabitEthernet0/0/1]port default vlan 11
[S1-GigabitEthernet0/0/1]interface GigabitEthernet 0/0/2
[S1-GigabitEthernet0/0/2]port link-type access
[S1-GigabitEthernet0/0/2]port default vlan 12
[S1-GigabitEthernet0/0/2]interface GigabitEthernet 0/0/3
[S1-GigabitEthernet0/0/3]port link-type access
[S1-GigabitEthernet0/0/3]port default vlan 13
[S1-GigabitEthernet0/0/3]interface GigabitEthernet 0/0/21
[S1-GigabitEthernet0/0/21]port link-type access
[S1-GigabitEthernet0/0/21]port default vlan 11
[S1-GigabitEthernet0/0/21]interface GigabitEthernet 0/0/22
[S1-GigabitEthernet0/0/22]port link-type access
[S1-GigabitEthernet0/0/22]port default vlan 12
[S1-GigabitEthernet0/0/22]interface GigabitEthernet 0/0/23
[S1-GigabitEthernet0/0/23]port link-type access
[S1-GigabitEthernet0/0/23]port default vlan 13
```

步骤二. 将接口配置到安全区域

防火墙上默认有四个区域，分别是“local “、” trust “、” untrust “、” dmz “。

实验中我们使用到“trust “、” untrust “和” dmz “三个区域。Ethernet 0/0/0默认就属于untrust区域，我们只需要将Ethernet 2/0/0加入DMZ区和将Vlanif 12加入trust区域即可。

```
[FW]firewall zone dmz
[FW-zone-dmz]add interface Ethernet 2/0/0
[FW-zone-dmz]firewall zone trust
[FW-zone-trust]add interface Vlanif 12
```

默认情况下，防火墙并不允许除local区域外的其它区域之间的通信。为了便于验证配置的正确性，我们首先将防火墙区域之间的默认过滤规则配置为允许所有区域间通信。配置完成后在FW设备上测试相同区域的连通性。

```
[FW]firewall packet-filter default permit all
[FW]ping 10.0.10.1
  PING 10.0.10.1: 56  data bytes, press CTRL_C to break
    Request time out
    Reply from 10.0.10.1: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.10.1: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.10.1: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.10.1: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.10.1 ping statistics ---
    5 packet(s) transmitted
    4 packet(s) received
    20.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[FW]ping 10.0.20.2
  PING 10.0.20.2: 56  data bytes, press CTRL_C to break
    Request time out
    Reply from 10.0.20.2: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.20.2: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.20.2: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.20.2: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.20.2 ping statistics ---
    5 packet(s) transmitted
```

```
    4 packet(s) received
    20.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[FW]ping 10.0.30.3
  PING 10.0.30.3: 56  data bytes, press CTRL_C to break
    Request time out
    Reply from 10.0.30.3: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.30.3: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.30.3: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.30.3: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.30.3 ping statistics ---
    5 packet(s) transmitted
    4 packet(s) received
    20.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

步骤三. 配置静态路由，实现网络的连通性

在R1、R2和R3上配置缺省路由，在FW上配置明确的静态路由，实现三个Loopback0接口连接的网段之间的互通。

```
[R1]ip route-static 0.0.0.0 0 10.0.10.254

[R2]ip route-static 0.0.0.0 0 10.0.20.254

[R3]ip route-static 0.0.0.0 0 10.0.30.254

[FW]ip route-static 10.0.1.0 24 10.0.10.1
[FW]ip route-static 10.0.2.0 24 10.0.20.2
[FW]ip route-static 10.0.3.0 24 10.0.30.3
```

配置完成后，测试各路由器Loopback0接口连接的网段之间的通讯情况。

```
[R1]ping -a 10.0.1.1 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Reply from 10.0.2.2: bytes=56 Sequence=1 ttl=254 time=3 ms
    Reply from 10.0.2.2: bytes=56 Sequence=2 ttl=254 time=3 ms
    Reply from 10.0.2.2: bytes=56 Sequence=3 ttl=254 time=4 ms
    Reply from 10.0.2.2: bytes=56 Sequence=4 ttl=254 time=2 ms
    Reply from 10.0.2.2: bytes=56 Sequence=5 ttl=254 time=3 ms
```

```
 --- 10.0.2.2 ping statistics ---
   5 packet(s) transmitted
   5 packet(s) received
   0.00% packet loss
   round-trip min/avg/max = 2/3/4 ms

[R1]ping -a 10.0.1.1 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=254 time=4 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=254 time=4 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=254 time=3 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=254 time=4 ms
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=254 time=4 ms

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 3/3/4 ms
```

步骤四. 配置区域间安全策略

配置区域之间的策略，首先将防火墙的区域间默认过滤策略配置为拒绝所有区域间通信，然后配置仅允许Trust区域访问其他区域，不允许其他区域之间的访问。

```
[FW]firewall packet-filter default deny all
[FW]firewall packet-filter default permit interzone trust untrust direction outbound
[FW]firewall packet-filter default permit interzone trust dmz direction outbound
[FW]firewall session link-state check
```

配置完成后，测试区域之间的连通性。

Untrust区域到Trust区域。

```
[R1]ping -a 10.0.1.1 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out
```

```
 --- 10.0.2.2 ping statistics ---
   5 packet(s) transmitted
   0 packet(s) received
   100.00% packet loss
```

Untrust区域到DMZ区域。

```
[R1]ping -a 10.0.1.1 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss
```

Trust区域到Untrust区域。

```
[R2]ping -a 10.0.2.2 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=254 time=3 ms
    Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=254 time=3 ms
    Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=254 time=3 ms
    Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=254 time=3 ms
    Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=254 time=3 ms

  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 3/3/3 ms
```

Trust区域到DMZ区域。

```
[R2]ping -a 10.0.2.2 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=254 time=5 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=254 time=3 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=254 time=3 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=254 time=4 ms
```

```
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=254 time=3 ms

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 3/3/5 ms
```

DMZ区域到Untrust区域。

```
[R3]ping -a 10.0.3.3 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss
```

DMZ区域到Trust区域。

```
[R3]ping -a 10.0.3.3 10.0.2.2
  PING 10.0.2.2: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.2.2 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss
```

步骤五. 配置允许 Untrust 区域访问 DMZ 区域的特定服务器

DMZ区域有一个服务器，IP地址为10.0.3.3，需要对Untrust区域开放Telnet服务，同时为了测试网络，需要开放ICMP Ping测试功能。

```
[FW]policy interzone dmz untrust inbound
[FW-policy-interzone-dmz-untrust-inbound]policy 1
[FW-policy-interzone-dmz-untrust-inbound-1]policy service service-set icmp
[FW-policy-interzone-dmz-untrust-inbound-1]policy destination 10.0.3.3 0
[FW-policy-interzone-dmz-untrust-inbound-1]action permit
[FW-policy-interzone-dmz-untrust-inbound-1]quit
[FW-policy-interzone-dmz-untrust-inbound]policy 2
[FW-policy-interzone-dmz-untrust-inbound-2]policy service service-set telnet
[FW-policy-interzone-dmz-untrust-inbound-2]policy destination 10.0.3.3 0
[FW-policy-interzone-dmz-untrust-inbound-2]action permit
[FW-policy-interzone-dmz-untrust-inbound-2]quit
[FW-policy-interzone-dmz-untrust-inbound]policy 3
[FW-policy-interzone-dmz-untrust-inbound-3]action deny
```

为了能在进行Telnet测试，在R3上开启Telnet功能。

```
[R3]user-interface vty 0 4
[R3-ui-vty0-4]authentication-mode none
```

测试网络连通性。

```
[R1]ping 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=254 time=3 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=254 time=2 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=254 time=2 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=254 time=4 ms
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=254 time=2 ms

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 2/2/4 ms

[R1]ping -a 10.0.1.1 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=254 time=3 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=254 time=2 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=254 time=2 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=254 time=2 ms
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=254 time=2 ms

  --- 10.0.3.3 ping statistics ---
```

```
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 2/2/3 ms

[R1]ping 10.0.30.3
  PING 10.0.30.3: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.30.3 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss

<R1>telnet 10.0.3.3
  Press CTRL_] to quit telnet mode
  Trying 10.0.3.3 ...
  Connected to 10.0.3.3 ...
<R3>quit

  Configuration console exit, please retry to log on

  The connection was closed by the remote host
<R1>telnet 10.0.30.3
  Press CTRL_] to quit telnet mode
  Trying 10.0.30.3 ...
```

如测试结果，显示区域之间的过滤情况，除了特定放行的数据流外，其他数据流被过滤掉了。

附加实验：思考并验证

实验中，可以使用防火墙来替代交换机，这样配置也更加方便。但是实际使用时，大部分情况下，使用的是实验中的场景。思考一下这样的场景规划有哪些好处？

最终设备配置

```
[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
interface GigabitEthernet0/0/1
 ip address 10.0.10.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.10.254
#
Return

[R3]display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
interface GigabitEthernet0/0/1
 ip address 10.0.30.3 255.255.255.0
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.30.254
#
user-interface con 0
user-interface vty 0 4
 authentication-mode none
user-interface vty 16 20
#
Return

[FW]display current-configuration
#
 sysname FW
#
 l2tp domain suffix-separator @
#
```

```
 firewall packet-filter default permit interzone trust untrust direction outbound
 firewall packet-filter default permit interzone trust dmz direction outbound
#
 ip df-unreachables enable
#
 vlan batch 1 12
#
 firewall statistic system enable
#
interface Vlanif1
#
interface Vlanif12
 ip address 10.0.20.254 255.255.255.0
#
interface Ethernet0/0/0
 ip address 10.0.10.254 255.255.255.0
#
interface Ethernet1/0/0
 portswitch
 port link-type access
 port access vlan 12
#
interface Ethernet2/0/0
 ip address 10.0.30.254 255.255.255.0
#
firewall zone local
 set priority 100
#
firewall zone trust
 set priority 85
 add interface Ethernet1/0/0
 add interface Ethernet1/0/1
 add interface Ethernet1/0/2
 add interface Ethernet1/0/3
 add interface Ethernet1/0/4
 add interface Ethernet1/0/5
 add interface Ethernet1/0/6
 add interface Ethernet1/0/7
 add interface Vlanif1
 add interface Vlanif12
#
firewall zone untrust
 set priority 5
```

```
 add interface Ethernet0/0/0
#
firewall zone dmz
 set priority 50
 add interface Ethernet2/0/0
#
aaa
 local-user admin password cipher %$%$r(sf.cF$A7%o4X%u-+AZ]6-$%$%$
 local-user admin service-type web terminal telnet
 local-user admin level 15
 authentication-scheme default
 #
 ip route-static 10.0.1.0 255.255.255.0 10.0.10.1
 ip route-static 10.0.2.0 255.255.255.0 10.0.20.2
 ip route-static 10.0.3.0 255.255.255.0 10.0.30.3
#
user-interface con 0
user-interface tty 2
 authentication-mode password
 modem both
user-interface vty 0 4
 authentication-mode aaa
 protocol inbound all
#
policy interzone dmz untrust inbound
 policy 1
  action permit
  policy service service-set icmp
  policy destination 10.0.3.3 0

 policy 2
  action permit
  policy service service-set telnet
  policy destination 10.0.3.3 0

 policy 3
  action deny
#
return
```

实验 9-3 USG 防火墙 NAT 配置

学习目的

- 掌握在USG防火墙上配置NAT Server的方法
- 掌握在USG防火墙上配置NAT Easy IP的方法

拓扑图

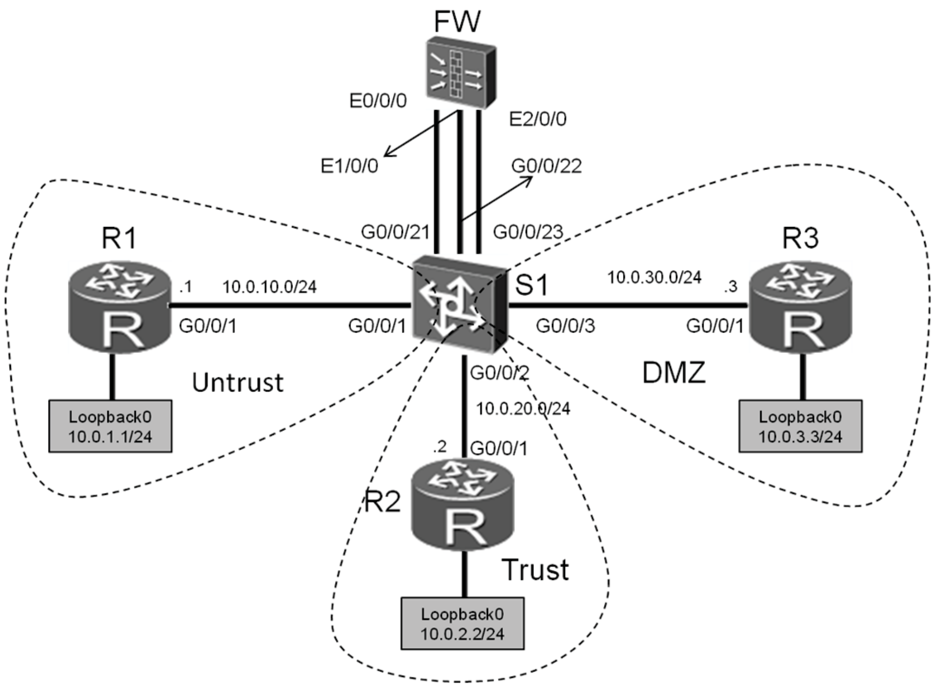


图9.4 USG防火墙NAT配置

场景

你是你们公司的网络管理员。公司的网络使用防火墙隔离成三个区域。现在需要将DMZ区域中的一台服务器（IP地址为10.0.3.3）提供的Telnet服务发布出去，对外公开的地址为10.0.10.20/24。并且内部网络Trust区域的用户通过Easy-IP的方式访问外部区域。其他方向的访问被禁止。

在交换机上将G0/0/1与G0/0/21接口定义到VLAN11，将G0/0/2与

G0/0/22接口定义到VLAN12，将G0/0/3与G0/0/23接口定义到VLAN13。分别规划了三个网段。

学习任务

步骤一. 基本配置与 IP 编址

首先给三个路由器配置地址信息。

```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R1
[R1]interface GigabitEthernet 0/0/1
[R1-GigabitEthernet0/0/1]ip address 10.0.10.1 24
[R1-GigabitEthernet0/0/1]interface loopback 0
[R1-LoopBack0]ip address 10.0.1.1 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R2
[R2]interface GigabitEthernet0/0/1
[R2-GigabitEthernet0/0/1]ip address 10.0.20.2 24
[R2-GigabitEthernet0/0/1]interface loopback 0
[R2-LoopBack0]ip address 10.0.2.2 24

<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]sysname R3
[R3]interface GigabitEthernet 0/0/1
[R3-GigabitEthernet0/0/1]ip address 10.0.30.3 24
[R3-GigabitEthernet0/0/1]interface loopback 0
[R3-LoopBack0]ip address 10.0.3.3 24
```

给防火墙配置地址时，需要注意Ethernet1/0/0接口为二层交换机接口，无法配置IP地址，实验中我们在防火墙上配置VLAN12，定义Vlanif12，配置IP地址作为Inside区域的网关，使用IP地址10.0.20.254/24。另外由于默认情况下防火墙会给它的Vlanif1接口配置地址，实验中为避免干扰，删除该配置。

```
<USG2100>system-view
Enter system view, return user view with Ctrl+Z.
[USG2100]sysname FW
[FW]vlan 12
[FW-vlan-12]quit
```

```
[FW]interface Vlanif 12
[FW-Vlanif12]ip address 10.0.20.254 24
[FW-Vlanif12]interface ethernet 1/0/0
[FW-Ethernet1/0/0]port  access vlan 12
[FW-Ethernet1/0/0]quit
[FW]interface Vlanif 1
[FW-Vlanif1]undo ip address
[FW-Vlanif1]quit
[FW]interface Ethernet 0/0/0
[FW-Ethernet0/0/0]ip address 10.0.10.254 24
[FW-Ethernet0/0/0]interface ethernet 2/0/0
[FW-Ethernet2/0/0]ip address 10.0.30.254 24
```

交换机上需要按照需求定义VLAN。

```
[Quidway]sysname S1
[S1]vlan batch 11 to 13
[S1]interface GigabitEthernet 0/0/1
[S1-GigabitEthernet0/0/1]port link-type access
[S1-GigabitEthernet0/0/1]port default vlan 11
[S1-GigabitEthernet0/0/1]interface GigabitEthernet 0/0/2
[S1-GigabitEthernet0/0/2]port link-type access
[S1-GigabitEthernet0/0/2]port default vlan 12
[S1-GigabitEthernet0/0/2]interface GigabitEthernet 0/0/3
[S1-GigabitEthernet0/0/3]port link-type access
[S1-GigabitEthernet0/0/3]port default vlan 13
[S1-GigabitEthernet0/0/3]interface GigabitEthernet 0/0/21
[S1-GigabitEthernet0/0/21]port link-type access
[S1-GigabitEthernet0/0/21]port default vlan 11
[S1-GigabitEthernet0/0/21]interface GigabitEthernet 0/0/22
[S1-GigabitEthernet0/0/22]port link-type access
[S1-GigabitEthernet0/0/22]port default vlan 12
[S1-GigabitEthernet0/0/22]interface GigabitEthernet 0/0/23
[S1-GigabitEthernet0/0/23]port link-type access
[S1-GigabitEthernet0/0/23]port default vlan 13
```

步骤二. 将接口配置到安全区域

防火墙上默认有四个区域，分别是“local “、” trust “、” untrust “、” dmz “。

实验中我们使用到“trust “、” untrust “和” dmz “三个区域。Ethernet 0/0/0

默认就属于untrust区域，我们只需要将Ethernet 2/0/0加入DMZ区和将Vlanif 12加入trust区域即可。

```
[FW]firewall zone dmz
[FW-zone-dmz]add interface Ethernet 2/0/0
[FW-zone-dmz]firewall zone trust
[FW-zone-trust]add interface Vlanif 12
```

默认情况下，防火墙并不允许除local区域外的其它区域之间的通信。为了便于验证配置的正确性，我们首先将防火墙区域之间的默认过滤规则配置为允许所有区域间通信。配置完成后在FW设备上测试连通性。

```
[FW]firewall packet-filter default permit all
[FW]ping 10.0.10.1
  PING 10.0.10.1: 56  data bytes, press CTRL_C to break
    Request time out
    Reply from 10.0.10.1: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.10.1: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.10.1: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.10.1: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.10.1 ping statistics ---
    5 packet(s) transmitted
    4 packet(s) received
    20.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[FW]ping 10.0.20.2
  PING 10.0.20.2: 56  data bytes, press CTRL_C to break
    Request time out
    Reply from 10.0.20.2: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.20.2: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.20.2: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.20.2: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.20.2 ping statistics ---
    5 packet(s) transmitted
    4 packet(s) received
    20.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[FW]ping 10.0.30.3
  PING 10.0.30.3: 56  data bytes, press CTRL_C to break
    Request time out
```

```
  Reply from 10.0.30.3: bytes=56 Sequence=2 ttl=255 time=1 ms
  Reply from 10.0.30.3: bytes=56 Sequence=3 ttl=255 time=1 ms
  Reply from 10.0.30.3: bytes=56 Sequence=4 ttl=255 time=1 ms
  Reply from 10.0.30.3: bytes=56 Sequence=5 ttl=255 time=1 ms

 --- 10.0.30.3 ping statistics ---
  5 packet(s) transmitted
  4 packet(s) received
  20.00% packet loss
  round-trip min/avg/max = 1/1/1 ms
```

步骤三. 配置静态路由，实现网络的连通性

在R2和R3上配置缺省路由，在FW上配置明确的静态路由，实现三个Loopback0接口连接的网段之间的互通。R1无需定义缺省路由，原因是其作为Internet设备，它不需要知道内部和DMZ区域的私有网络信息。

```
[R2]ip route-static 0.0.0.0 0 10.0.20.254

[R3]ip route-static 0.0.0.0 0 10.0.30.254

[FW]ip route-static 10.0.1.0 24 10.0.10.1
[FW]ip route-static 10.0.2.0 24 10.0.20.2
[FW]ip route-static 10.0.3.0 24 10.0.30.3
```

在防火墙上测试与10.0.1.0、10.0.2.0、10.0.3.0三个网段的连通性。

```
[FW]ping 10.0.1.1
 PING 10.0.1.1: 56  data bytes, press CTRL_C to break
  Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=255 time=1 ms
  Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=255 time=1 ms
  Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=255 time=1 ms
  Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=255 time=1 ms
  Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=255 time=1 ms

 --- 10.0.1.1 ping statistics ---
  5 packet(s) transmitted
  5 packet(s) received
  0.00% packet loss
  round-trip min/avg/max = 1/1/1 ms

[FW]ping 10.0.2.2
 PING 10.0.2.2: 56  data bytes, press CTRL_C to break
```

```
    Reply from 10.0.2.2: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.2.2: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.2.2: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.2.2: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.2.2: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.2.2 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms

[FW]ping 10.0.3.3
  PING 10.0.3.3: 56  data bytes, press CTRL_C to break
    Reply from 10.0.3.3: bytes=56 Sequence=1 ttl=255 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=2 ttl=255 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=3 ttl=255 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=4 ttl=255 time=1 ms
    Reply from 10.0.3.3: bytes=56 Sequence=5 ttl=255 time=1 ms

  --- 10.0.3.3 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
    round-trip min/avg/max = 1/1/1 ms
```

目前配置下，所有区域之间可以正常通讯，不被检查。但是由于当前尚未定义NAT，外部区域不能与内部和DMZ区域相互访问。

步骤四.　配置区域间的安全过滤

配置从Trust区域的部分网段10.0.2.0发往Untrust区域的数据包被放行。从Untrust区域发往DMZ目标服务器10.0.3.3的Telnet请求被放行。

```
[FW]firewall session link-state check
[FW]policy interzone trust untrust outbound
[FW-policy-interzone-trust-untrust-outbound]policy 0
[FW-policy-interzone-trust-untrust-outbound-0]policy source 10.0.2.0 0.0.0.255
[FW-policy-interzone-trust-untrust-outbound-0]action permit
[FW-policy-interzone-trust-untrust-outbound-0]quit
[FW-policy-interzone-trust-untrust-outbound]quit
[FW]policy interzone dmz untrust inbound
[FW-policy-interzone-dmz-untrust-inbound]policy 0
```

```
[FW-policy-interzone-dmz-untrust-inbound-0]policy destination 10.0.3.3 0
[FW-policy-interzone-dmz-untrust-inbound-0]policy service service-set telnet
[FW-policy-interzone-dmz-untrust-inbound-0]action permit
[FW-policy-interzone-dmz-untrust-inbound-0]quit
```

步骤五. 配置 Easy-IP，实现 Trust 区域到 Untrust 区域的访问

配置使用Easy-IP，进行NAT源地址转换。并且将NAT与接口进行绑定。

```
[FW]nat-policy interzone trust untrust outbound
[FW-nat-policy-interzone-trust-untrust-outbound]policy 0
[FW-nat-policy-interzone-trust-untrust-outbound-0]policy source 10.0.2.0
0.0.0.255
[FW-nat-policy-interzone-trust-untrust-outbound-0]action source-nat
[FW-nat-policy-interzone-trust-untrust-outbound-0]easy-ip Ethernet 0/0/0
```

配置完成后，验证Trust区域与Untrust区域之间的访问是否正常。

```
[R2]ping 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Request time out
    Request time out
    Request time out
    Request time out
    Request time out

  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    0 packet(s) received
    100.00% packet loss

[R2]ping -a 10.0.2.2 10.0.1.1
  PING 10.0.1.1: 56  data bytes, press CTRL_C to break
    Reply from 10.0.1.1: bytes=56 Sequence=1 ttl=254 time=4 ms
    Reply from 10.0.1.1: bytes=56 Sequence=2 ttl=254 time=3 ms
    Reply from 10.0.1.1: bytes=56 Sequence=3 ttl=254 time=3 ms
    Reply from 10.0.1.1: bytes=56 Sequence=4 ttl=254 time=3 ms
    Reply from 10.0.1.1: bytes=56 Sequence=5 ttl=254 time=3 ms

  --- 10.0.1.1 ping statistics ---
    5 packet(s) transmitted
    5 packet(s) received
    0.00% packet loss
```

```
   round-trip min/avg/max = 3/3/4 ms
```

注意，这里直接测试与10.0.1.1之间的连通性，显示不通。使用扩展Ping，指定了发送数据包的源地址为10.0.2.2后，实现了连通性。原因是，直接发送数据包到10.0.1.1时，数据包的源地址为10.0.20.2，该地址不属于NAT转换的客户端地址范围。

步骤六. 将内网服务器 10.0.3.3 发布出去

配置内网服务器10.0.3.3的Telnet服务，映射到地址10.0.10.20。

```
[FW]nat server protocol tcp global 10.0.10.20 telnet inside 10.0.3.3 telnet
```

在R3上开启Telnet功能，并在R1上测试，测试时需注意，对外发布的地址为10.0.10.20，所以R1对10.0.3.3访问时，访问的目标地址应为10.0.10.20。

```
[R3]user-interface vty 0 4
[R3-ui-vty0-4]authentication-mode none

<R1>telnet 10.0.10.20
  Press CTRL_] to quit telnet mode
  Trying 10.0.10.20 ...
  Connected to 10.0.10.20 ...
<R3>
```

附加实验：思考并验证

在发布内网服务时，我们选择了比较简单的应用Telnet，如果需要发布FTP应用，原理和配置方面会有怎样的差异。

请从FTP应用的两种模式（主动模式和被动模式）上去考虑防火墙会怎样处理这些数据。

最终设备配置

```
[R1]display current-configuration
[V200R001C01SPC300]
#
 sysname R1
#
```

```
interface GigabitEthernet0/0/1
 ip address 10.0.10.1 255.255.255.0
#
interface LoopBack0
 ip address 10.0.1.1 255.255.255.0
#
Return

[R2]display current-configuration
[V200R001C01SPC300]
#
 sysname R2
#
interface GigabitEthernet0/0/1
 ip address 10.0.20.2 255.255.255.0
#
interface LoopBack0
 ip address 10.0.2.2 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.20.254
#
Return

[R3]display current-configuration
[V200R001C01SPC300]
#
 sysname R3
#
interface GigabitEthernet0/0/1
 ip address 10.0.30.3 255.255.255.0
#
interface LoopBack0
 ip address 10.0.3.3 255.255.255.0
#
 ip route-static 0.0.0.0 0.0.0.0 10.0.30.254
#
user-interface con 0
user-interface vty 0 4
 authentication-mode none
user-interface vty 16 20
#
Return
```

```
[FW]display current-configuration
#
 sysname FW
#
 l2tp domain suffix-separator @
#
 firewall packet-filter default permit interzone local trust direction inbound
 firewall packet-filter default permit interzone local trust direction outbound
 firewall packet-filter default permit interzone local untrust direction inbound
 firewall packet-filter default permit interzone local untrust direction outbound
 firewall packet-filter default permit interzone local dmz direction inbound
 firewall packet-filter default permit interzone local dmz direction outbound
 firewall packet-filter default permit interzone trust untrust direction inbound
 firewall packet-filter default permit interzone trust untrust direction outbound
 firewall packet-filter default permit interzone trust dmz direction inbound
 firewall packet-filter default permit interzone trust dmz direction outbound
 firewall packet-filter default permit interzone dmz untrust direction inbound
 firewall packet-filter default permit interzone dmz untrust direction outbound
#
 nat server 0 protocol tcp global 10.0.10.20 telnet inside 10.0.3.3 telnet
#
 ip df-unreachables enable
#
 firewall ipv6 session link-state check
 firewall ipv6 statistic system enable
#
interface Vlanif1
#
interface Vlanif12
 ip address 10.0.20.254 255.255.255.0
#
interface Ethernet0/0/0
 ip address 10.0.10.254 255.255.255.0
#
interface Ethernet1/0/0
 portswitch
 port link-type access
 port access vlan 12
#
interface Ethernet2/0/0
 ip address 10.0.30.254 255.255.255.0
#
interface NULL0
```

```
#
firewall zone local
 set priority 100
#
firewall zone trust
 set priority 85
 add interface Ethernet1/0/0
 add interface Ethernet1/0/1
 add interface Ethernet1/0/2
 add interface Ethernet1/0/3
 add interface Ethernet1/0/4
 add interface Ethernet1/0/5
 add interface Ethernet1/0/6
 add interface Ethernet1/0/7
 add interface Vlanif1
 add interface Vlanif12
#
firewall zone untrust
 set priority 5
 add interface Ethernet0/0/0
#
firewall zone dmz
 set priority 50
 add interface Ethernet2/0/0
#
 ip route-static 10.0.1.0 255.255.255.0 10.0.10.1
 ip route-static 10.0.2.0 255.255.255.0 10.0.20.2
 ip route-static 10.0.3.0 255.255.255.0 10.0.30.3
#
policy interzone trust untrust outbound
 policy 0
  action permit
  policy source 10.0.2.0 0.0.0.255
#
policy interzone dmz untrust inbound
 policy 0
  action permit
  policy service service-set telnet
  policy destination 10.0.3.3 0
#
nat-policy interzone trust untrust outbound
 policy 0
  action source-nat
```

```
 policy source 10.0.2.0 0.0.0.255
 easy-ip Ethernet0/0/0
#
return
[FW]
```

第十章 综合实验

实验 10-1 综合实验

学习目的

- 掌握帧中继的配置方法
- 掌握VLAN的配置方法
- 掌握VLAN路由的配置方法
- 掌握OSPF的配置方法
- 掌握OSPF在NBMA网络的工作模式
- 掌握DHCP的配置方法
- 掌握DHCP中继的配置方法
- 掌握防火墙的配置方法
- 掌握NAT的配置方法

拓扑图

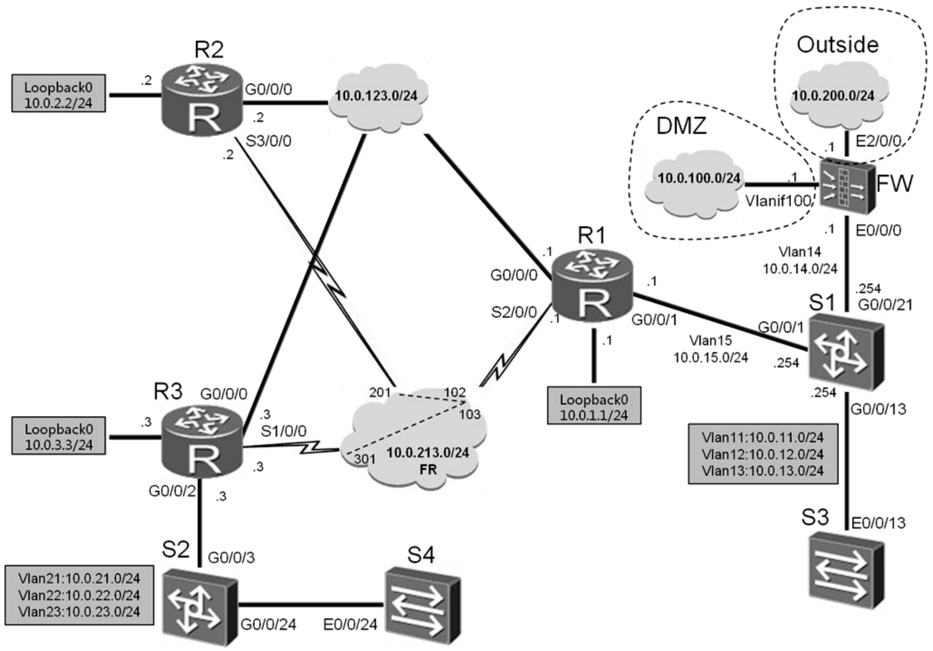


图10.1 综合实验

场景

你是公司的网络管理员。公司的网络分成了三部分，路由器R1在总部，这里有DMZ区域、内部网络（包括三个VLAN）和外部网络区域；路由器R3在公司分部（包括三个VLAN）；路由器R2在分支办公室，只有一个网段。公司的三个网段通过帧中继互联；后来考虑到网络冗余，租用了专线。接口及编址信息如图所示。

学习任务

步骤一. 基本配置与 IP 编址

注意由于本综合实验的目的在于检测学员对前面19个实验学习掌握的程度，所以本实验仅给出步骤和验证方式，不给出具体的操作命令。

依照拓扑图配置IP地址、VLAN信息，并且配置帧中继网络，最终实现所有直连网络的连通性。

配置时需要注意S1配置多层交换，对应Vlanif的接口IP地址为254；其他交换机都不使用多层交换功能。R3使用物理接口G0/0/2提供子接口为VLAN21、22、23提供服务；帧中继接口上关闭Inarp功能，手动定义PVC的DLCI和IP的对应关系，同时注意R2和R3之间没有虚电路；在防火墙上，需要注意E1/0/0接口连接到DMZ，但是不能配置IP地址，我们使用VLANif100接口来替代，配置IP地址，并且在防火墙上删除缺省的VLANif1接口。

步骤二. 配置全网的 OSPF

配置OSPF，需要在R1、R2、R3、S1、FW上配置OSPF，所有网段属于区域0。在帧中继网络接口上OSPF以默认的网络类型NBMA模式工作。

另外需要特别注意，将所有没有必要发送OSPF信息的接口定义为OSPF的Silent-interface。并且在10.0.123.0/24网段启用MD5认证，密码为“huawei”。

在FW上配置缺省路由，下一跳指向IP地址10.0.200.2，并将此缺省路由发布到OSPF区域，使用类型1，度量值为20，定义为永久发布。

步骤三. 配置 DHCP 服务

在R1上配置DHCP服务，为网段10.0.11.0/24、10.0.12.0/24、10.0.13.0/24、10.0.21.0/24、10.0.22.0/24、10.0.23.0/24提供自动获取地址的功能。配置中DNS服务器IP配置为10.0.200.200，地址有效期为3小时。

在R3设备上需要配置DHCP Relay，确保VLAN21、22、23网段的用户可以获取到地址。

在S4上配置VLANif23，测试DHCP功能。

在S3上配置VLANif13，测试DHCP功能。

步骤四. 在 FW 上配置防火墙功能

在FW设备上配置防火墙功能，实现公司网络可以访问外部网络的功能，但是外部网络不能访问内部网络和DMZ网络，同时DMZ网络不能访问任何网络，默认情况下内部网络也不能访问DMZ网络。

在DMZ区域有一台服务器，IP地址为10.0.100.11/24，提供Telnet、FTP、HTTP服务。其中HTTP服务对所有区域开放；FTP服务对内部所有地址开放；

Telnet服务仅对10.0.13.100/24地址开放。

步骤五. 在 FW 上配置 NAT 功能

在FW设备上配置NAT功能，使用Easy-IP功能，允许所有内部网段通过NAT地址转换访问外部区域。

附加实验：思考并验证

为了考查学习的知识点，本次实验网络设计成当前的拓扑图。思考这样的拓扑图在实际使用中，有哪些优点和缺点？

最终设备配置

```
[R1]display current-configuration
```

```
[R2]display current-configuration
```

```
[R3]display current-configuration
```

```
[S1]display current-configuration
```

```
[S2]display current-configuration
```

```
[S3]display current-configuration
```

```
[S4]display current-configuration
```

```
[FW]display current-configuration
```